KNOWLEDGE

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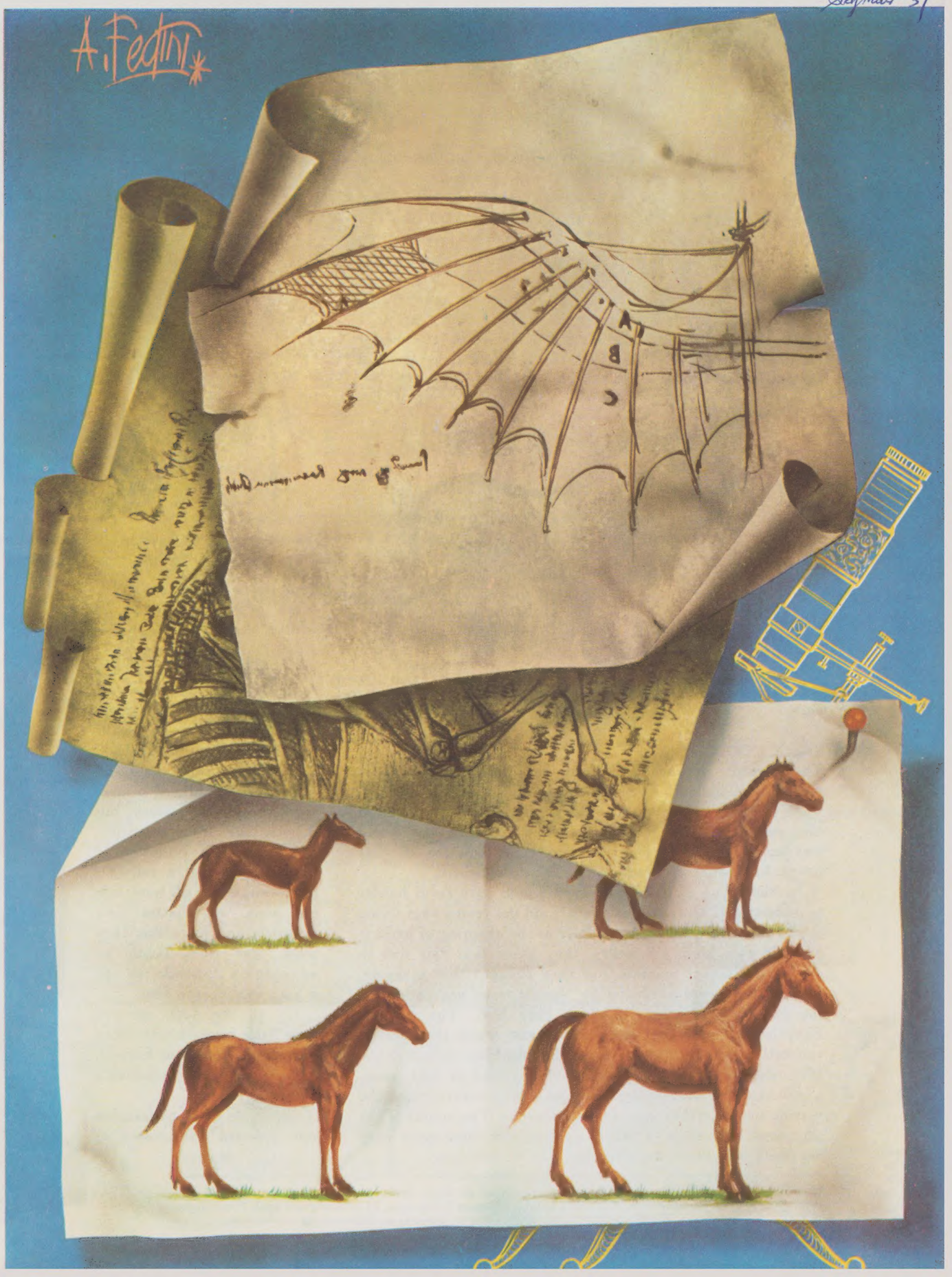

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Z ZOOLOGY (part one)

ZOOLOGY is the scientific study of animals, just as botany is the study of plants; these two are branches of the whole study of life, which is known as biology. A professional zoologist may be employed in animal management in a zoo or nature reserve, or in a museum or marine-biological station. He may be concerned with economic zoology – that is, with making practical use of animals or controlling their numbers if they become numerous enough to be pests; or he may be a teacher of zoology in a school or university. Remember that to a zoologist the word animal means a member of the animal kingdom; a jelly-fish or a beetle is just as much an animal as a rat or a horse.

The legendary unicorn, which men thought for centuries was a real animal

EARLY ZOOLOGY

The scientific approach of the modern zoologist is quite a recent development. Even as late as the mid-18th century, when the picture above was drawn, people firmly believed in unicorns. This was not unreasonable because the world was inadequately explored at that time, and for all that people knew such creatures might exist somewhere.

Another type of belief prevailed which may seem harder to understand. The early naturalists did not realise that living things can only come into existence as the offspring of parents of their own kind. Of course, they knew that this was so among the higher animals, but they thought that maggots, for instance, were produced by 'spontaneous generation' in the putrefying matter in which they live. The Ancient Egyptians thought that the scarab beetle, which they held in veneration, was born out of the mud of the Nile. As late as the 16th century it was still believed that a kind of wild goose, whose breeding habits were unknown, was generated from the marine shelled crustaceans called barnacles. The monks of the time took advantage of this to declare that these geese were not 'flesh' and could therefore be eaten on fast-days!

A HISTORY OF ZOOLOGY

The sacred scarab beetle of the Ancient Egyptians

The history of zoology as a science can be said to begin with the Greek philosopher Aristotle (384–322 B C). He was the first to propose a systematic and natural classification of animals, which he divided into two major groups, according to whether they possessed red blood or not; these groups corresponded to our vertebrates and invertebrates. He had sufficient understanding of the subject to realise that whales and dolphins are not fish, but are related to the four-footed land mammals. Although Aristotle was such an accurate observer, he upheld the theory of spontaneous generation and believed that a swarm of bees could be produced from the carcass of an ox. The truth of this matter is, of course, that flies of a species which looks like a bee lay their eggs in the carcass, and the same kind of fly emerges from it. After Aristotle the Greeks and Romans did not make much progress in zoology. The Roman Pliny the Elder (A D 23–79) produced a large work on natural history, but it was far from scientific. Pliny was no observer of animals, but just a collector of stories, which all went into his book, no matter how fantastic and incredible they were. Far from being an advance on Aristotle, he fell a long way behind him.

Up to the 13th century very little interest was taken in natural science in Europe. About that time Aristotle's

Aristotle, the Greek philosopher who founded the science of zoology

Previous page: (above) anatomical drawings by Leonardo da Vinci; (below) evolution of the horse: *Eohippus* (Eocene, 60 million years ago); *Mesohippus* (Oligocene, 25 million years ago); *Merychippus* (Miocene, 20 million years ago); modern horse; (centre) an 18th-century microscope.

HEADWATERS
HERE 1467 FEET ABOVE THE OCEAN
THE MIGHTY MISSISSIPPI BEGINS TO FLOW ON ITS
WINDING WAY TO THE GULF OF
MEXICO 2546 MILES

The sign marking the source of the Mississippi at Lake Itasca in north-west Minnesota

THE MISSISSIPPI

WINDING through the forests and swamps lying to the west of Lake Superior are several small streams; south of New Orleans, nearly 2,500 miles farther on, a mighty river enters the Gulf of Mexico through a delta of its own construction. These are the headwaters and mouth of one of the greatest rivers in the world – the Mississippi. With its many tributaries – notably the Missouri – it drains about one-eighth of North America.

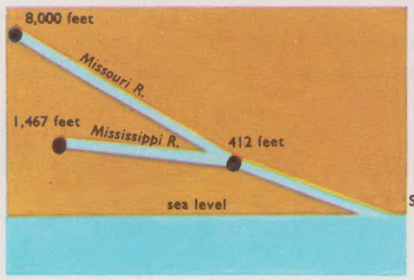
But even when the headwaters of the Missouri are taken as the source, the Mississippi is not the longest river in the world; the Nile and the Amazon are just a little longer. It drains a much smaller area and carries a smaller volume of water than either the Amazon or the Congo. The shipping figures of the relatively short St Lawrence, with its recently opened Seaway (see page 369), dwarf those of its bigger neighbour. But to Americans the Mississippi will always be the first of rivers, while the works of Mark Twain and its appearance in innumerable 'westerns' have made it familiar to thousands of foreigners.

The Upper Mississippi

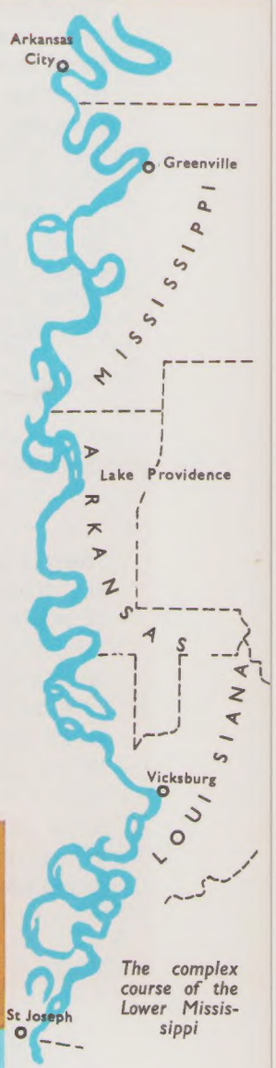
The exact source of the Mississippi is uncertain, but it is usually taken to be Lake Itasca in north Minnesota. In its upper reaches the river meanders through pleasant country, sometimes widening to form tree-fringed lakes, sometimes narrowing to cross tumbling rapids, before descending the Falls of St Anthony at the twin cities of Minneapolis and St Paul. The river will soon be diverted around these falls by a series of locks. Below these falls it is navigable until it reaches the sea.

The Missouri

The headwaters of the Missouri consist of three rivers: the Jefferson, the Madison, and the Gallatin, whose sources are some 8,000 feet up in the Rockies. They unite near Helena, the capital of Montana, before pouring through the great gorge known as 'The Gates of the Mountains'. Here the water level drops over 300 feet in a series of cascades and falls. But downstream the turbulence is restricted by the vast Fort Peck Reservoir, which is part of a large-scale project to control this great river. The Missouri has cut a deep channel into the weaker rocks of the Great Plains, and the floor of the valley, which is sometimes 15 miles wide, lies 100 to 300 feet below the surface of the land. The powerful current is constantly eroding the banks, so that every year millions of tons of good soil are absorbed by the river, which is nicknamed 'The Big Muddy'. The cottonwoods and willows that line the banks are frequently toppled into the river, and together with changing currents, varying water levels, and dangerous sandbars, they make navigation very hazardous. After being joined by a number of major tributaries, notably the Yellowstone and the Platte, the Missouri merges with the Mississippi some 17 miles above St Louis, the greatest city of the whole valley. Its muddy yellow waters contrast strongly with the clear waters of the Upper Mississippi, and it is many miles before the two mingle completely.



Section showing heights on the Mississippi



The complex course of the Lower Mississippi

The meeting of the Mississippi and the Missouri, some 17 miles north of St Louis

The Lower Mississippi

The combined Mississippi-Missouri flows southwards from St Louis. At Cairo it is joined by the Ohio, which, with its three main tributaries, the Tennessee, the Cumberland, and the Wabash, drains much of the relatively wet north-eastern United States. Heavy rains here can so increase the volume of water in the Ohio that serious floods may occur in the Lower Mississippi valley. The Mississippi-Ohio confluence is similar to that with the Missouri, in that the clear waters of the Ohio flow for many miles before being absorbed by the muddy waters of the main stream. Farther south the Arkansas and Red rivers add their burden of silt to the Mississippi.

The flood plain

The flood plain of the Mississippi begins near Cairo and extends for over 1,000 miles to the Gulf of Mexico. It is characterised by tortuous meanders which frequently develop a horseshoe shape before being cut off to form 'ox-bow' lakes. The main channel is constantly changing as new meanders are formed, while there are numerous man-made cuts. Much of the low-lying ground between this complex of channels is marshy 'bottom land'. Floods used to be frequent, but successive layers of silt have built up banks alongside the river (*levees*), and with artificial strengthening these afford protection against all but the severest floods. The plain is not monotonously flat as are those of some great rivers, for the low ridges and shallow depressions (*bayous*) that mark former natural levees and meanders give it an interesting if subdued relief.

But the flood menace has not been entirely banished from the Mississippi valley, in spite of protective measures dating from the building of the first levees in New Orleans in 1717. A number of serious floods have occurred during this century, as in 1937 when the cost of the damage was estimated at 350,000,000 dollars, and three-quarters of a million people were made temporarily homeless. At Cairo the water level rose 56 feet and the area inundated in the

THE DELTA

Not the least remarkable feature of the Mississippi is its delta, which is of the 'crow's foot' type. It is formed of material deposited by the river, which at the apex of the delta splits into several separate channels, called 'passes'. Day by day the 'feet' of the delta are extending into the Gulf of Mexico at the rate of 1 mile in 16 years. During 150 years the delta has added some 150 square miles to the United States.

A modern counterpart of the Mississippi steamboat

lower valley was nearly as large as Lake Superior. Flood-control measures aim to regularise the flow of the upper river by dams and reservoirs (as at Fort Peck) and to limit the area of flooding in the lower reaches by levees. But these banks need constant attention and periodic strengthening.

The Mississippi basin

The golden era of the Mississippi

Not surprisingly, the Mississippi is of considerable significance as an inland waterway, although its importance has decreased since its heyday in the first half of the 19th century. After the Louisiana Purchase (1803), by which the United States obtained from France extensive tracts west of the Mississippi, the lower part of the basin became one of the greatest cotton-growing regions in the world. The deep, rich, alluvial soils and long hot summers were ideally suited to the crop, while Negro slaves provided abundant labour. But the owners of the cotton plantations depended on the Mississippi for contact with the outside world, for food from the farmlands of the north, and for the export of the cotton via New Orleans, the city which dominated the whole of the lower valley. Steamboats packed high with bales of cotton became a familiar sight, and 'showboats' and floating gambling saloons catered for the leisure moments of the numerous traders and travellers. The steamboat, with its two tall, slender funnels and its giant paddle wheels, still remains the symbol of the golden era of the Mississippi.

A cargo barge passes the swing bridge near Hannibal on the Upper Mississippi

The Mississippi today

The spread of the railways brought a rapid decline in the trade on the Mississippi, which became a barrier to the increasing east-west movement. But during this century there has been some recovery, largely through government investment in channel improvements and shipping. Today the river is used mainly for the long-distance movement of heavy bulk goods.

THE EXPLORATION OF THE MISSISSIPPI VALLEY

Long before the coming of the white man, the Mississippi had been given its name by the Indians, who called it the 'Great River' (*Missi Sipi*) or 'Father of Waters'. It is thought that Columbus may have seen its mouth, but the first European to stand on its banks was Hernando de Soto, who reached it by an overland route in 1541. But de Soto died there, and the river remained unexplored for a century. In 1673 two Frenchmen, Father Jacques Marquette and Louis Jolliet, sailed down the Mississippi to its junction with the Arkansas, and in 1682 La Salle made the first complete voyage to the sea. The Missouri was not explored until 1804 to 1806, when Lewis and Clark, at the request of President Jefferson, made their epic pioneer journey up the river and across the Rockies to the Pacific coast. As the settlement of the United States moved westward the Mississippi valley became first a frontier zone and then a jumping-off stage for journeys farther west, the valleys of its great right-bank tributaries providing easy routes to the Great Plains.

The Mississippi has fulfilled its destiny as the base for the opening up of the West, for today its drainage basin (which covers two-fifths of the United States) contains most of the country's richest farmlands as well as valuable mineral and industrial resources.

Facts and Figures

	Length (miles)	*Area of drainage basin (sq miles)*
Mississippi-Missouri	3,896	1,243,000
Missouri	2,475	530,000
Upper Mississippi	1,200	171,500

Flow of the Mississippi (cubic feet per second): maximum 1,557,000
minimum 49,200
average 513,000

Total navigable distance in the entire basin ..... 15,000 miles

Tokyo, September 1923, shattered by an earthquake. 250,000 people were estimated to have lost their lives in the disaster, and £1,000 million worth of damage was done

NEARLY every year the world is horrified by a major disaster caused by an earthquake. In some, thousands of people are killed and hundreds of thousands rendered homeless. Perhaps the most disastrous earthquake ever occurred in Japan in 1923 in which the greater part of Tokyo and Yokohama was completely destroyed.

This earthquake struck at about midday. The shaking of the earth was so violent that potatoes flew from the ground. It occurred at a time when most of the inhabitants of the two cities were cooking their meals on charcoal braziers. The force of the earthquake knocked these over, and soon many of the flimsy Japanese houses were ablaze. The earthquake also broke the water mains, so the fire brigades were powerless.

Some figures put the death role at 250,000. It was said that 40,000 people were burned alive in the yard of a clothing factory. Half the brick houses in Tokyo were flattened. About £1,000 million worth of damage was done.

The centre of the shock was Sagani Bay which, after the earthquake, was found to be as much as 690 feet deeper in some parts. A great wave accompanied the earthquake and did further damage along the sea front.

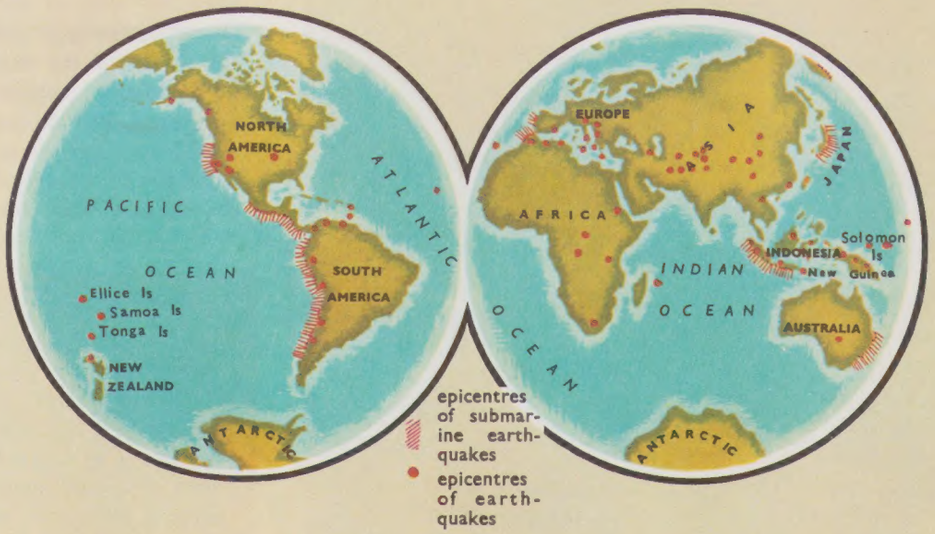
To the early peoples earthquakes were even more terrifying than they are today – for then their cause was not known.

Early Greeks believed that the god Poseidon was angry when earthquakes occurred. The Cretans tried to pacify the earth by the sacrifice of bulls. Yet their great palace at Knossos was flattened by an earthquake. Later Greek thinkers came to the conclusion that earthquakes were caused by storms in huge underground caverns.

Today we know the causes of earthquakes to be continual processes of structural adjustment within the solid structure of the earth – a process against which man is quite powerless.

50,000 EARTHQUAKES A YEAR

Earthquakes of the magnitude of the Tokyo disaster in 1923 are fortunately rare; however, the earth is not completely quiet between these major tragedies. Each day about 90 earth tremors are recorded – they are usually too gentle to be felt by man, but do register on very sensitive instruments called seismographs. They indicate that, on a small scale, parts of the earth's crust are being strained, fractured, or buffeted. Whatever the reason, measurable vibrations of varying degrees of intensity are caused.



Earthquakes occur in parts of the world where 'mountains are young'. That means they have only recently (in geological terms) been formed. There are two great belts in which earthquakes occur: one is the 'Ring of Fire' which encircles the Pacific Ocean and in which the Tokyo earthquake occurred; the other stretches across southern Asia along the Mediterranean. There is an offshoot of the latter down the Red Sea and into East Africa. In these areas the mountains are young, and so the earth's crust is in some of these places still in an unsettled state.

CRUST (20 miles thick)
UPPER MANTLE (750 miles thick)
LOWER MANTLE (1,200 miles thick)
OUTER CORE (1,300 miles thick)
INNER CORE (750 miles thick)

INSIDE THE EARTH

The earth is divided into a number of layers. The direct causes of earthquakes are found in the outer layer – the *crust*; the innermost layers – the *inner core* and *outer core* – have no direct influence on them. Above the earth's core is its mantle. In the upper layers of the mantle volcanic eruptions originate. As we shall see later, the effect of volcanic eruptions on the

There are various layers beneath the earth's surface. The direct cause of an earthquake is movement in the top layer – the crust. (The layers on the left are not drawn exactly to scale and the figures are approximate)

EARTHQUAKES

earth's crust can cause a certain type of earthquake. The earth's crust is above the outer mantle. This layer – on average about 20 miles thick – is by no means settled. It has numerous structural flaws (called *faults* by the geologists), and it is the movement of rocks resulting from these flaws that causes earthquakes. Major flaws are found mainly in regions of recent mountain formation like the 'Ring of Fire'. There are also flaws in areas of old mountains, but here the major flaws have by now settled down and little movement of rocks is associated with them. That is why so few earthquakes occur in Great Britain and northern Europe, because the mountains here are old ones.

CAUSES OF EARTHQUAKE

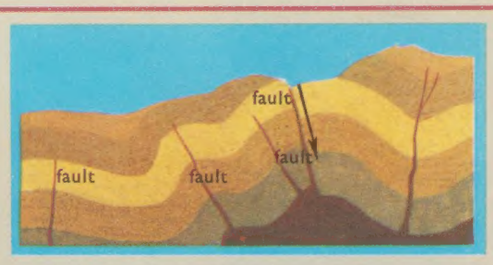
An earthquake is a violent vibration of the earth's surface. An earth tremor is a similar vibration but nothing like as intense. In an earthquake the surface of the earth may rise and fall by several feet. The 'quake may last up to a minute or be a matter of seconds. Its result may be to bring great buildings down or just a few slates off a roof. The point where the earthquake begins is known as its *epicentre*. This is the area of maximum shock. The compression waves from the earthquake can be recorded thousands of miles away. However, its destructive effects may be felt over no more than, say, ten miles from its epicentre.

Earthquakes have three main causes:

1. *Collapse of subterranean caverns.* An underground stream can, by erosion, excavate large caverns in the body of the earth and then, later, cause the roofs of these caverns to collapse. Whole towns have been swallowed up in this way. It happened to the city of Avezzano, in Italy, in 1915. The direct consequences of these earthquakes can be terrible, but they are quite rare.

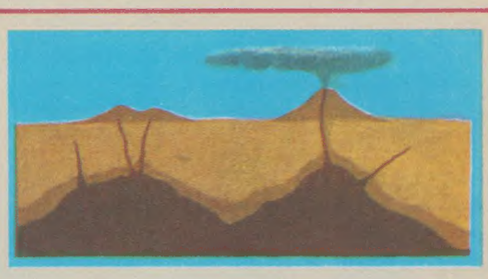
① *Roof of underground cavern collapsing*

2. *Tectonic.* This type is associated with major flaws in the earth's crust. The crust may suddenly slip downwards or to the side. Huge masses of rock shift, and the subterranean movement causes a tremor on the earth's surface. Sometimes the surface of the earth itself cracks. A horrifying example of a tectonic earthquake was in 1906 in San Francisco. Cracks measuring over 20 feet wide in the ground were by no means uncommon.

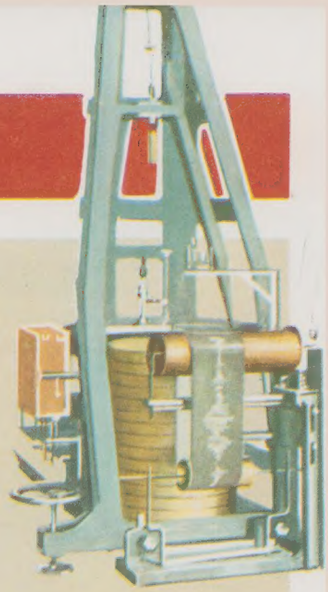


② *Tectonic movement: because of a fault in the earth's surface one layer of rock has slipped down. The movement results in an earthquake*

3. *Volcanic.* In the upper mantle of the earth there is a zone of semi-fluid rocks which are not very stable. Inside them a tremendous pressure is built up, and they are constantly searching for openings in the earth's crust which will relieve the pressure. The effect of this pressure on the earth's crust can result in considerable subterranean movement which in its turn results in an earthquake.

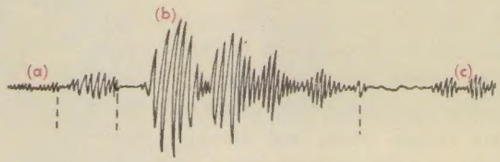


③ *Volcanic earthquake: beneath the surface are semi-fluid rocks whose upward pressure can cause considerable disturbance in the earth's crust*



The seismograph, a machine for measuring earthquakes

Below is a seismogram (what the seismograph records). (b) is the climax of the earthquake; (a) and (c) are a record of minor tremors



SEISMOLOGY

This is the branch of science devoted to the study of earthquakes, and the seismograph is the instrument that is used to measure these phenomena. This sensitive mechanism can pick up a tremor up to 12,500 miles away from its origin. When there is little movement within the earth's crust the seismogram records a slightly agitated line (a). The line becomes more distorted (b) when the tremors grow more severe. The lines are drawn on a revolving drum that is linked to a clock mechanism; it is, therefore, possible to gain a true measure of the exact time, force, and position of the earthquake. The intensity is stated in terms of the Mercalli scale; on this the effect of the earthquake is related to a scale of 12 degrees. In Degree I the tremor is only detectable by seismographs. At the other end of the scale, Degree XII, the earthquake is a 'major catastrophe' and involves total destruction. The character of the seismic wave can be affected by the rock through which it passes – that is, by its structure and density.

SUBMARINE EARTHQUAKES

Along coasts earthquakes are often complemented by gigantic waves known as *tsunamis*. They are caused by severe submarine earthquakes that induce subsidence on the ocean floor. In the Lisbon earthquake of 1755 such waves were up to 40 feet high at Lisbon itself and destroyed the lower parts of the city. This earthquake was even felt at Loch Lomond, Scotland, where the water rose and fell through a range of 3 feet.

SAUDI ARABIA: HISTORY

THE Arabian peninsula is a vast area of land, none of which is fertile and much of which is virtually uninhabitable. The kingdom of Saudi Arabia extends over about nine-tenths of it. This kingdom is more than six times the size of Britain, yet Britain's population is eight times that of Saudi Arabia. The reason for the lack of people is lack of water. Nowhere are there more than 10 inches of rain a year (in parts of Britain there are more than 100 inches), and in some parts there is hardly any rainfall at all. The Arabs long for rain and think of it as God's greatest blessing. There are no rivers or streams; but the ground in some places is so stony and hard that when rain falls it does not seep down beneath the surface but rushes away in a torrent, sweeping away whole villages and drowning both animals and men.

The animal best adapted for life in the desert is the camel. The desert Arab's life (see page 2142) is dependent on his camels (as his camels' lives are on him, for they do not exist in the wild state). He travels from place to place with them, looking for pasturage and seldom resting; he sleeps in a camel-hair tent, eats camels' meat and drinks camels' milk, sings his songs to them, and rides on their backs.

Saud, who became King of Saudi Arabia in 1953

Mecca: Islam's Holy City

AN ANCIENT TRADE ROUTE

Since ancient times Arabia has been important as a trade route between the Mediterranean Sea and the Indian Ocean, and thus between Europe and the Far East. Today the main trade route is through the Red Sea and the Suez Canal, but before the invention of the steamship in the early 19th century the Red Sea route was not practicable, and most of the trade came overland up the western side of Arabia. This was the reason for the widespread (but false) belief that beyond *Arabia Deserta* ('Arabia the deserted') lay *Arabia Felix* ('Arabia the fortunate'). The latter was thought to be fabulously rich in all the silks and spices that were really coming from India and beyond to the port of Aden, and thence, by camel, into the interior of the fabulous country. It is certainly true that the Yemen, which lies at the southern tip of Arabia, is more fertile than the rest of the peninsula, but it certainly does not support this legend of Arabia Felix.

MECCA, ARABIA'S HOLY CITY

The most famous town on the western Arabian trade route is Mecca. It was in Mecca, in the 6th century, that Mahomet was born and began to propagate the religion of Islam (see page 1552); within a century the Arabs had carried Islam throughout an empire stretching from the borders of France in the west to those of India in the east (see page 732). Yet, before the 6th century had passed, the centre of the new empire had been moved – first to Damascus in Syria and then to Baghdad in Iraq. Arabia once again became the backwater that it has been at most times in its history.

Mecca is no longer a centre of political power or even of trade, but it is still a holy city. Even before the time of Mahomet pilgrims used to visit a black stone at Mecca, traditionally given by the Archangel Gabriel to Abraham, and this same stone is now the focus of the pilgrimage to Mecca which is obligatory for all Muslims (those who profess the religion of Islam). The tomb of Mahomet is not at Mecca but at Medina, not far away, another holy city and place of pilgrimage.

No one who is not a Muslim is allowed to enter Mecca, though a number of Christians have succeeded in doing so. Perhaps the most famous of these was Sir Richard Burton, the English explorer (see page 2156), whose fantastic gift for languages enabled him to disguise himself as an Afghan holy man and to go on a pilgrimage to Mecca in 1853. If he had been detected it would have meant certain death. Afterwards he wrote a book about his experience.

THE SHAPING OF SAUDI ARABIA

The present kingdom of Saudi Arabia dates only from 1932. It is a union of two countries ruled by the same king, for the King of Saudi Arabia is both the Sultan of Nejd and King of the Hejaz. Its origins go back to the 18th century, when a violent and puritanical Muslim sect, the Wahhabis, made themselves masters of Nejd, an independent state in central Arabia. They sacked many cities, including Mecca. Their leaders were a family of princes called Sa'ud. But the Wahhabis were later crushed by the mighty Ottoman Empire, which took Mecca and even occupied Riyadh, the Nejd capital.

For almost a century Wahhabis had to suffer Turkish rule, until Ibn Saud came out of the desert with a small force and took Riyadh in 1901. By 1913 Ibn Saud had driven the Turks out of the Nejd. After the First World War he added to his kingdom. King Hussein of the Hejaz had claimed overlordship of Arabia – the Wahhabis replied by capturing his kingdom, which stretched from Transjordan in the north to Asis (now also part of Saudi Arabia) in the south. In 1926 Ibn Saud proclaimed himself King of the Hejaz, and in 1932 the joint kingdom was renamed Saudi Arabia. The present King is Ibn Saud's son.

FANTASTIC RICHES

In 1938 a group of American companies found oil in eastern Saudi Arabia. The development of oil production on a vast scale has profoundly changed both the economic situation in Saudi Arabia and its importance to the rest of the world. Nearly one-tenth of the world's oil supplies now comes from Saudi Arabia, and the Saudi government receives about £150 million a year in taxes from the oil companies, who in their turn benefit the country by bringing water and providing medical, educational, and other services.

Much of this money has been used wastefully, but much is now being spent on improving the condition of the people who, until now, have been some of the poorest on earth.

FACTS AND FIGURES

Area: 927,000 square miles
Population: 6,000,000
Density of population: 6 per square mile
Capital: Riyadh (population 100,000)
Religion: Islam

A brightly coloured tropical member of the Orthoptera; its name is Tapezia spumans

THE ORTHOPTERA (part one)

'Green little vaulter in the sunny grass,
Catching your heart up at the feel of June,
Sole voice that's heard amid the lazy noon.'

THESE lines from the sonnet *To the Grasshopper and the Cricket* by Leigh Hunt (1784–1859) clearly state the chief characteristics of the Order Orthoptera to which these insects belong: they jump and they sing.

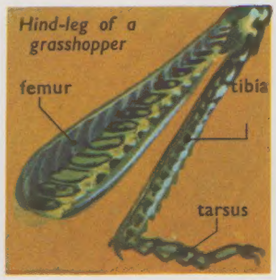
All grasshoppers, and most other Orthoptera, have the hindmost of their three pairs of legs much longer and stronger than the others. By suddenly straightening out these legs they perform flying leaps that make them difficult to catch. If you hold a grasshopper in your closed hand you will be surprised at the strength of its kicking.

Most people have heard grasshoppers singing in a field or crickets chirping in a house. Like most insects that have voices, they produce their 'singing' by a method called *stridulating*. If you take a rather fine file and draw your finger-nail quickly along it, you can make a faint, high-pitched squeak. Stridulating is noise-producing of this kind, and all the vocal Orthoptera have some arrangement of little ridges on their limbs and wings, which are rubbed together to make their song. Usually only the males sing in order to attract the females. Both sexes have hearing organs; the 'ears' of some kinds are at the base of the abdomen, and of others on the fore-legs.

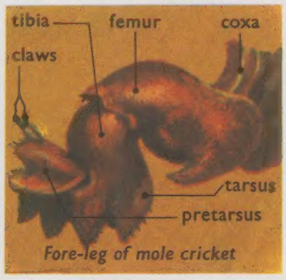
The common grasshoppers and crickets are pleasant, harmless little insects, but the large grasshoppers called locusts are among the worst insect scourges of mankind. When locusts become very numerous they migrate, travelling across the land, breeding as they go, and eating every growing plant and green leaf in their path.

SOME COMMON CHARACTERISTICS

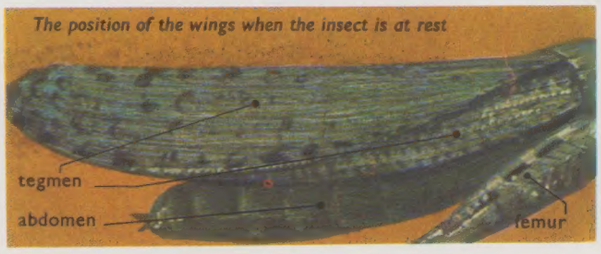
All Orthoptera have biting mouth-parts with strong mandibles. Most of them have well-developed eyes



The hindmost legs are often developed for jumping; the femur is the longest and stoutest joint



The fore-legs are usually walking limbs, but in some Orthoptera they are specially modified for digging



In the flying species of Orthoptera the fore-wings are narrower than the hind-wings and are usually rather thick and leathery. They are called *tegmina* (each one is a *tegmen*) and they serve as protective covers for the hind-wings, which are quite broad but are folded like fans under the tegmina when the insect is at rest. Most Orthoptera (except locusts) fly only short distances, if at all.

INCOMPLETE METAMORPHOSIS

When a grasshopper hatches it differs from its parents only in size and absence of wings. Each time it sheds its skin it grows, and its wings develop a little more. There are no larva and pupa stages as in a butterfly, an insect with complete metamorphosis; Orthoptera have incomplete metamorphosis.

THREE MAIN GROUPS

The Orthoptera are classified in three main groups.

Long-horned grasshoppers (Tettigoniidae). These insects live mostly among the foliage of trees and stridulate by rubbing together specially modified areas of the left and right fore-wings or tegmina. They have long, slender antennae and 'ears' on their front legs, and the females have blade-like egg-laying organs or *ovipositors*. Their tegmina are often coloured and shaped to look like leaves and so camouflage the insects. Some of them depart from the usually vegetarian habits of the Orthoptera and prey on other insects.

Crickets and mole crickets (Gryllidae and Gryllotalpidae). Most of the crickets are small, stout-bodied insects that live on the ground and sometimes enter houses. Mole crickets are extraordinary insects, with very powerful fore-legs adapted for burrowing in the soil. Antennae, stridulating and hearing organs, and ovipositors are similar to those of the long-horned grasshoppers.

Short-horned grasshoppers and locusts (Acrididae). These insects have short antennae and they stridulate by rubbing the femur against the fore-wing of each side. Their hearing organs are at the base of their abdomens, and the ovipositors of the females are short. We shall describe the short-horned grasshoppers in a later article.

House cricket

House cricket (*Gryllus domesticus*). As its name suggests, this is a 'domestic' insect, found in northern Europe living in buildings like bakeries and houses where fires are kept going all the winter. Sometimes house crickets go outside in warm summer weather, and they occasionally live in the warmth surrounding permanently-smouldering rubbish heaps.

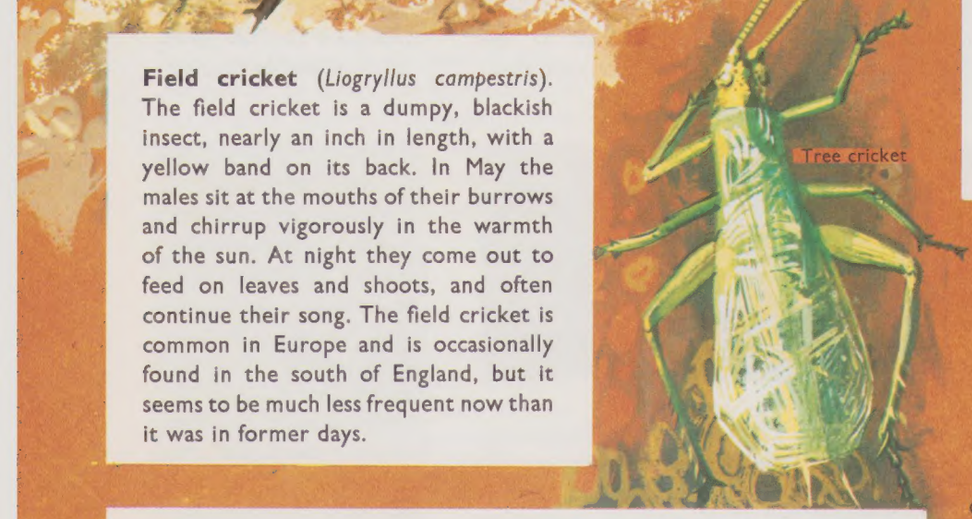
The 'song' of the house cricket is very shrill, and not everyone can hear it. It is a pleasant, cheerful noise, and provided there are not too many of them there is no reason why you should not occasionally welcome crickets in your house.

Field cricket

Mole cricket

Mole cricket (*Gryllotalpa gryllotalpa*). This large insect may be over 2 inches long. It lives almost entirely underground but sometimes flies about at night. It feeds on other insects but is unpopular with gardeners as its tunnellings cut through the roots of plants. Its fore-legs are very strong, armed with claws for digging and curiously like the fore-paws of a mole. If you hold a mole cricket in your closed hand it will force its

Field cricket (*Liogryllus campestris*). The field cricket is a dumpy, blackish insect, nearly an inch in length, with a yellow band on its back. In May the males sit at the mouths of their burrows and chirrup vigorously in the warmth of the sun. At night they come out to feed on leaves and shoots, and often continue their song. The field cricket is common in Europe and is occasionally found in the south of England, but it seems to be much less frequent now than it was in former days.



Tree cricket

Tree cricket (*Oecanthus pellucens*). This is one of a group of true crickets that live among trees, not on the ground. An American species has been found to time its chirping according to the temperature. If you count the number of chirps in 15 seconds and add 39, this will give the temperature quite accurately in degrees Fahrenheit.

Great green grasshopper

Great green grasshopper (*Tettigonia viridissima*). This is a large grasshopper (with long, thread-like antennae) that is fairly common in southern England. The females are larger than the males and easily recognisable by the long, sword-shaped

Knowledge News

AUGUST 1964

JOURNEY TO THE FORGOTTEN WORLD

PHOTOS BY THOMAS PAKENHAM

Led by Alice Chancellor the expedition sets out

JOURNEY TO THE FORGOTTEN WORLD

'No place for a woman' was how the High Simien was described to ALICE CHANCELLOR in Addis. Few Ethiopians and even fewer Europeans had been to this strange area, which might be a section of the moon fallen to earth. Parts of it are over 15,000 feet. It is castellated with jagged mountains that make the Alps look tame, and gashed with gorges that rival the Grand Canyon. There are no roads, no wheel-drawn vehicles, and no stone houses. Little has changed in the last thousand years. Despite tales of hardship and bandits, 26-year-old Alice Chancellor with a group of her British friends set out to visit this forgotten world. Alice went not only for adventure, but to report to her husband, John Chancellor, Managing Editor of Knowledge and Animals, on the walia ibex, one of the world's rarest animals. Here is an account of the expedition based on her diary

The pictures above and on the cover give an idea of the jagged, spectacular scenery of the Simien. Also on the cover: Alice Chancellor, and a mediaeval painting of St George, the patron saint of Ethiopia

15th March

We set off from Debarec on 15th March after waiting for five long, tedious hours having an argument—mules versus horses. In Gondar a doctor had said to us: 'Take mules, two of my horses died.' After a five-hour investigation of the transport situation we left—on horses. One or two looked very shaky.

However, we were well equipped for the journey. We had tents—orange ones called 'The Good Companions' with tough oilskin ground-sheets—anoraks, string vests, rubber-soled climbing boots, sleeping-bags, and lots of jerseys. I had a balaclava, which was to make hanging around in the early morning waiting to load up less painful. But we were to find that the cold, although bitter, never made it difficult to sleep at night. During the day I spent a lot of time shedding layers of clothing and draping them on my horse. Then just as I began to feel cold I would sometimes find that I had lost sight of my animal.

We left the town surrounded by a mob of children. Every schoolboy in Debarec was there. Many spoke English:

'Where do you come from?'

'London.'

'Then you are Great British.'

At first we rode over a highland rolling gently upwards. There were grassy slopes and streams. It was rather like parts of Yorkshire. In the evening sunlight we camped on the edge of an enormous canyon.

Camping always followed a regular pattern. Our specially provided escort of Ethiopian soldiers—three guards called Yohannis, Daniel, and Asfa—and Gabriel, our cook, helped unload. We put up the three tents, while villagers fetched water and food. A tiny but efficient fire was built, and *tchai* (Ethiopian tea) boiled. Tchai is made in a kettle, drunk with lots of sugar and no milk, and is the best tea in the world.

The villages provided *injerra* and *wat* for our soldiers and muleteers. Injerra and wat are eaten three times a day by all Amharas (the Ethiopians who live in this area). Injerra is pancake-shaped, thin, brown-grey, and spongy; it is always a little damp and has a rather sour taste. If you eat it with jam or honey and you haven't eaten real bread for a very long time, then it tastes very good indeed. Otherwise not. Wat is made with berberris berries, and is a type of curry. It burns your mouth, tongue, and lips—and goes on burning them for about 10 minutes!

Generally *talla* (Ethiopian beer) arrived in a great earthenware jar. If the village was a rich village, the inhabitants also gave us chickens and eggs, *dabo* (dark-brown oat-bread like Hovis), and milk and honey in earthen jars.

We were travelling during *Tom* (Coptic Lent). No Ethiopian could eat any meat, milk, eggs, or butter at all. We often felt embarrassed opening our tins of steak, tongue, and paté, or eating fried chicken and bacon and scrambled eggs. But we were too hungry in the evenings to feel very guilty.

16th March

When we made our first big descent next morning we passed a group of monkeys—geladas, who chattered and snarled at us. Nobody paid any attention except one of the baggage-horses. It was startled, leaped into the air, and disappeared bouncing and sliding about 300 feet down the almost vertical hillside. Its back was broken, and the poor thing died. By the evening we had plodded up the other side of the canyon to the village of Enchetkab, which is 10,500 feet above sea-level.

17th March

The next day we walked for four hours along the plateau to Derazghie—the administrative centre of the Simien and seat of a *Keniazmach* (meaning right-hand man in battle), or local governor. It has a large, very handsome church built in 1870; also groves of eucalyptus trees, a school, and a few tiny shops.

The Keniazmach gave us lunch in his house. We took our cook and our food, which he tasted politely. We tasted his injerra and wat equally politely, except that as usual we suffered from terribly burned mouths. There was a great deal of ritual pouring of water over our hands before and after the meal from a small enamel kettle.

Our host, a dynamic, enthusiastic, and jolly man who had fought with much valour against the Italians, sat, as is the custom, at a table by himself, beaming at us and striking a bell in front of him to call his attendants. We drank talla and aniseed liqueur from very small tin egg-cups, and we paid

him very elaborate compliments through an interpreter.

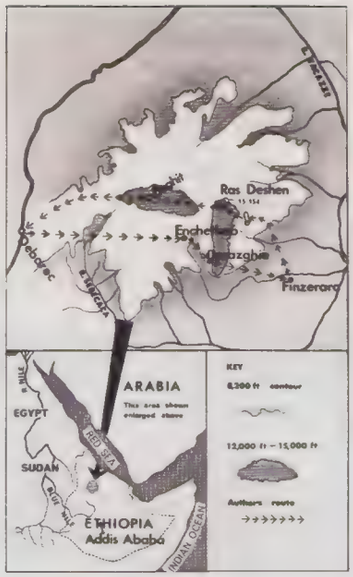
There are more than 100 priests at Derazghie. With their help we photographed and filmed the church treasure: fantastic crosses and crowns made of finely and elaborately wrought silver and gold; gold-worked Bibles; red and purple vestments; and lovely golden drums which are beaten during the Dance of David, one of the central ceremonies of the Coptic Church.

We explored two churches built into the cliffs nearby. One, Abba (Saint) Anna, was in a cave (in Amharic 'washa') and contained 50 or 60 skeletons and mummies. The legend is that they were originally holy hermits who lived on grass; the man who brought them the grass died, and so they died too—all on the same day, St George's Day.

But now we had to toil back up the mountain to our horses waiting at the top. The rest of the party had ridden on to a new camping-site. It grew later and later; the sun set firmly at 6.30; two of our guides ran back to Derazghie terrified. We had to go on. The rest of the baggage, tents, food, and all the men were waiting for us 10 miles away. It was completely dark and grew colder. But a light-hearted young trumpeter (provided for us by the Keniazmach from his bodyguard) bounded on in front with a torch, and at 9 o'clock, to my amazement, we found our camp. Everybody ran out and shook us by the hand and shouted and laughed. We warmed ourselves by the fire and felt marvellously happy. That day we had walked and ridden 10 hours.

18th March

The following day we plunged down a canyon—the Mai Shaha, a most fantastic gorge very like the Grand Canyon. We now had the core of the Simien—Ras Deshen—in view. Huge, dark cliffs loomed opposite across the abyss. It took nearly four hours to reach the bottom of the valley and a village called Mahe. Sometimes the path was much too steep to do anything but slide. We passed a small caravan of donkeys laden with sacks of grain. The dozen or so men bowed and greeted us.



The Simien is one of the most primitive areas of one of the world's most colourful countries and the most mountainous part of a country of mountains. The people there are Amharas—an ancient Semitic people, who belong to the Coptic Church, one of the earliest Christian Churches. The highest mountain is Ras Deshen (15,154 feet). It is the highest mountain in Ethiopia and the fourth highest in Africa. (*Above right*) A much-needed rest before tackling Buahit

19th March

Next morning early I was woken by shouts, and Yohannis told me that armed bandits had attacked the caravan we had passed, and taken their donkeys, grain, and 180 Ethiopian dollars (about £25). Only one of their party had been hurt—a small boy who had been stabbed in the bottom. I washed the wound with iodine and water, and dressed it with cotton-wool and elastoplast.

We moved on up the opposite side of the gorge. One felt like a fly toiling up a huge wall. At the top the land was covered with huge stones. It was a wilderness of muddy stream-beds and deep ruts. We reached Finzerara at 4 o'clock, exhausted and hungry. We had started at 6 o'clock in the morning. Daniel said: 'Let's play football here.'

20th March

Next day we rode northwards towards Ras Deshen across moor-like, but easy, country. We camped very close to the summit at about 12,000 feet—our highest camp.

Frozen hail, which had piled during a storm, lay in crevices. The air felt thin, and we celebrated this camp by eating a pot of Oxford marmalade that we had carried religiously with us. We also finished our whisky.

At night it was very cold. I slept in a sleeping-bag, a blanket, three vests, two jerseys, a shirt, an anorak, and a balaclava helmet. I wore my boots and two pairs of socks.

Ras Deshen is a mountain you can walk up, but every 10 yards, like a very old lady, you have to stop and get your breath.

21st-27th March

The following night we stopped on the other side of the peak of Mai Abo. It was lower and warmer. Our next long day took us round the northern end of the Mai Shaha Canyon and up over the Pass of Buahit at 14,000 feet. It seemed an unending climb; but when I got to the top, heart pounding, completely out of breath, and with three new blisters and a strong feeling of mutiny, it was worth it. So we had conquered the Simien. We were now at the northern end of the range, and in the territory of the walia ibex. We managed to catch a few glimpses of this rare animal, which is nearly extinct. I shall be writing about it in Animals magazine. When we turned back we took a different route, and after a leisurely two-day ride we arrived at Debarec.

(*Above*) The Simien has no stone houses; here the expedition passes a typical village. (*Above right*) Most of the Simien churches possess beautiful religious paintings like these of St Michael and the Virgin and Child. (*Right*) The Keniazmach (local governor) surrounded by his retainers

Knowledge News August 25th 1572

PARIS gutters run with blood in St Bartholomew's Day horror

MASSACRE!

Coligny

COMMENT

We are ready!

ARE the events in France the first of a general onslaught of Catholic Europe against the Protestants?

In Spain violent, cruel methods have been taken to suppress what the Catholics regard as heretical faiths; while in the Netherlands the Spaniards are making increased efforts to root out Protestantism.

But perhaps it is not the Calvinists of the Netherlands or even the Huguenots of France that have most to fear from the results of the St Bartholomew Massacre. Now England herself is exposed to the Catholic menace. For should the Catholic party succeed in dominating France and reach an understanding with Spain, then the Catholic monarchs may make common cause to implement the Papal Bull which, two years ago, excommunicated our Queen Elizabeth and urged Catholic forces to depose her.

Already that Bull has had consequences. The so-called Ridolfi plot, which brought England's only duke—Thomas Howard of Norfolk—to the block last June, was an attempt

By Our Paris Correspondent August 24th

Today I have witnessed a city in the throes of violence and cruelty unsurpassed since the fall of Constantinople. As I write this, Protestant corpses lie in the Paris streets. Flames rise from the gutted Protestant dwellings.

Coligny

Since dawn thousands of Protestants have been murdered. Even the greatest have not been spared.

Among the dead is Gas-

Catherine surveys her handiwork

GAINS FOR 'SEA BEGGARS'

Further gains for the 'Sea Beggars' are reported from the Netherlands. Several new towns have gone over to their side, and the rebellion against Spain is spreading among the Dutch.

These gallant Dutch seamen—known contemptuously by the Spaniards as 'Sea Beggars'—opened a new phase in the Netherlands' revolt against Spain, when last April they made a spectacular attack on the ports of Brille and Flushing.

But the big problem in Netherlands is the attitude of William of Orange, known as 'the Silent'.

He is not only the acknowledged spokesman of Dutch Protestants, but is known to command a great following among Dutch Catholics who would like to see the end of Spanish dominion.

But the extremism of the fanatical Calvinist 'Sea Beggars' could well mean alienating the Catholic and moderate support enjoyed by William. Will he decide to throw in his lot with

Howard of Norfolk—to the block last June, was an attempt to rouse English Catholics against the Queen.

Moreover, Mary, former Queen of Scots, remains a dangerous prisoner in England and perpetual focus of cunning Catholic plots seeking to place her on Elizabeth's throne.

Across the waters His Most Catholic Majesty, Philip II of Spain, has been receiving messages from England's Catholics informing him that our nation is seething with discontent and ready to flock to his Catholic banner should he choose to invade. The signs are ominous.

We must pray that the cause of moderation may yet prevail in France and that Spain will be prevented from invading by common sense and by her commitments in the Netherlands.

But if wiser counsels fail we can say to those who plot a 'St Bartholomew' in the streets of London: 'We are ready.' If this is indeed the eve of England's greatest test, Englishmen will not be found wanting—to preserve our nation from the marching boots of foreign soldiers.

Smiling

SPANISH eyes are smiling, and it is rumoured that the news of the St Bartholomew Massacre caused the only smile ever to flicker across the countenance of Spain's long-faced king.

This is not surprising, for the Guises represent the Spanish party in France.

During the last civil war the Guises were allied with Spain, and Spanish troops fought for them against the Huguenots.

The Guises' triumph will be doubly welcome to Philip, for Coligny was pressing for French intervention against Spain in the Netherlands.

Gloomy

RARELY has the plight of France been so gloomy. Another civil war looms large over the tortured country, which is rent by faction and religious strife. And rarely has a French king been so ineffectual. The weakness of 22-year-old Charles IX and the chaos of his kingdom are not unconnected.

Charles has never been a significant figure in French politics. It is rumoured that he is of an unbalanced mind and subject to hallucinations.

His failure to rise above the dissensions of his kingdom and provide a focus of national aspirations is one reason for France's pitiable state today. Moreover, as the tool of a faction himself, he has encouraged the conflicting parties within France to compete for his support.

spared.

Among the dead is Gaspard de Coligny, Admiral of France and the country's most prominent Protestant leader. He was flung naked from the window of his house.

Henry of Navarre—who only last Monday married the king's sister—and other Protestants are prisoners.

Planned

The massacre was a planned attempt to end the political influence of the French Protestants (Huguenots). It is thought that the guiding spirit was Catherine de Medici, mother of the king and power behind the French throne.

The slaughter began at dawn. As the great bell of the Palace of Justice rang out, the Catholics of Paris went to their gruesome work. Protestant houses were entered and pillaged. The inhabitants were flung screaming from the windows.

Shouting, stabbing, and strangling, the Parisians poured into the streets, leaving a trail of butchery and carnage. None was spared; high-born leaders, personal enemies of the mighty Guise family, and Huguenot artisans fell in the protracted blood-bath.

And vengeance pursued the Protestants even after their death. Their corpses were foully mutilated by the hysterical Catholic mobs.

Naked

Reports of similar atrocities flowed into Paris from the provinces—like that of the nobleman who forced his Huguenot maid-servant to stand naked in a rising stream until it covered and drowned her. Today is St Bartholomew's Day. Its name will be forever engraved as one of the bloodiest episodes in the history of France.

Can Huguenots make a come-back?

The executioner's axe hangs perilously over the head of Henry of Navarre, on whom the mantle of Protestant leadership has now fallen. But he is imprisoned, along with other leading Huguenots, in the Louvre.

Only last Monday Henry was the centre of festivities and celebrations in Paris, for on that day he married the king's sister, Margaret of Valois.

The marriage was condemned by orthodox Catholics as 'mixed' and was regarded as a distasteful symbol of the Huguenots' increasing triumphs.

These triumphs had begun with their victory in the civil war which ended two years ago with the Peace of St Germain.

By this peace the rights of worship of the Protestant nobility and townships had been guaranteed and the Huguenots secured a number of military strongholds. Huguenot successes reached a climax with the domination of the young king by Admiral Coligny, which even eclipsed the influence of his mother, Catherine de Medici.

So the thousands of Huguenots flocked to Paris to celebrate their growing triumphs. But few of them will return.

Yet despite the strength of the Catholic party it is unlikely that the Huguenots will accept defeat and exclusion from the government of France. They are strongly entrenched in several fortresses including that of La Rochelle.

The outbreak of an even more terrible civil war is the prospect facing France as a result of the St Bartholomew Massacre.

CATHERINE BETWEEN TWO FIRES

Catherine de Medici, almost certainly the instigator of yesterday's massacre, is today in an unenviable position.

She has earned the undying hatred of her Huguenot subjects. But she is not a member of the powerful Guise faction, which now dominates France—and she cannot necessarily look to it for support.

Her main motive in authorising the massacre was to end Coligny's influence over her 22-year-old son, Charles IX. Moreover, she strongly opposed the policy Coligny advocated of attacking the Spanish Netherlands, already in revolt against its rulers.

But few in France can have much sympathy for this terrible woman, who is striving so desperately for political power.

Is Queen's romance with Alençon on rocks?

There has been much speculation at Court about the effect of the news of the St Bartholomew Massacre on the rumoured romance between Elizabeth and the French Duke of Alençon.

The growing friendship between England and France, cemented last April by the Treaty of Blois, seemed an appropriate atmosphere for this romance. But if, as seems likely, there is a sharp diplomatic change as a result of the pitiless treatment of the Huguenots, a marriage between Elizabeth and a French prince would appear to be out of the question.

Mad-cap Act

Thomas Parsons, a 15-year-old London apprentice, has been fined 3s. 4d. for not wearing a woollen cap. His fine was under the terms of an Act which came into force last year, designed to foster England's vital wool trade. The Act ordained that every person over the age of six (except ladies, lords, knights, and gentlemen holding land to the annual value of 20 marks) should wear on their heads on Sundays and Holydays one cap of wool manufactured in England.

EUROPE WATCHES

The St Bartholomew Massacre has altered the political situation in Europe, and rulers are anxiously watching the outcome

Philip of Spain

Elizabeth

Catherine of France

Pope Gregory XIII

enjoyed by William. Will he decide to throw in his lot with the small band of sailors holding a few ports in Holland? The answer could prove decisive in the struggle of the Netherlands for independence.

CATHOLIC FINED

A 19-year-old Roman Catholic girl, Mary Vane, has been fined for recusancy under the laws which came into force at the beginning of the reign. For failure to attend church on 12 consecutive Sundays she has had to pay 12s. Her comment was that it was a small price to pay for the salvation of her soul.

GRISLY PRESENT FOR POPE

The Guises have sent the head of their arch-enemy, Coligny, as a grisly present to the Pope. So this influential family has got its revenge on the man who upset their fortunes and defeated them so soundly in the civil war of two years ago.

The Guise family is now fantastically powerful. Its leader is the Cardinal Archbishop of Rheims. 15 bishoprics are held by Guises, as well as numerous high civil offices. Daughters of the family have married kings of France and Scotland, and vast areas of French soil are in Guise hands.

NO NEWS OF DRAKE

Still no news of Francis Drake. Last May he set out from Plymouth with two vessels and a crew of 70. Reliable sources indicate that his intentions were to raid the Spanish Main in search of treasure-ships leaving Spain's New World colonies.

Such a plan would be in keeping with the feelings aroused by the unprovoked attack by an overwhelming force of Spaniards on a trading mission led by Sir John Hawkins (and including Drake) four years ago.

English seamen are indignant at the Spaniards' attempt to monopolise trade with the New World. Nevertheless the Queen is known to disapprove of these privateering activities, and has constantly expressed her wish to continue to live in friendship with Spain.

MOTOR SPRINTERS!

A dramatic view of one of America's top drag-racing competitors, Tony Nancy, taken by a camera mounted on the car's engine block

The brakes screech and a tightly packed cluster of cars jockey dangerously for position as they round the corner. Then, exhausts roaring, they race away at full speed. . . .

All this is a conventional sight at an ordinary race-meeting, and spectators and competitors agree it is quite exciting enough.

But in the United States a new and highly unconventional motor sport has already captured the public's imagination.

The sport is called drag racing. Only two cars race at a time. There are no corners. The cars often slow down by parachutes instead of brakes! **And each race is over in a matter of seconds.**

Drag racing, or 'hot rodding', began in a highly amateur way with a few enthusiasts who 'sooped' their cars to perform at remarkable speeds. But in America it is now a highly organised sport.

The National Hot Rod Association sanctions some 2,500 clubs and supervises 120 racing 'strips', or tracks. It also insists on certain safety precautions—such as asbestos suits and face-masks for the drivers.

The essence of hot rodding is simple. Two 'dragsters' line up alongside, the starting flag is lowered, and they race off down the track (which is only a quarter of a mile long).

What kind of cars compete in this sport? There are several types. **Sedans,** which are simply super-charged family cars, can reach 145 mph. **Gassers,** which are modified still further, can hit 170 mph. **Rails,** consisting of engines, a pair of bicycle wheels in front, and little else, reach 180-190 mph.

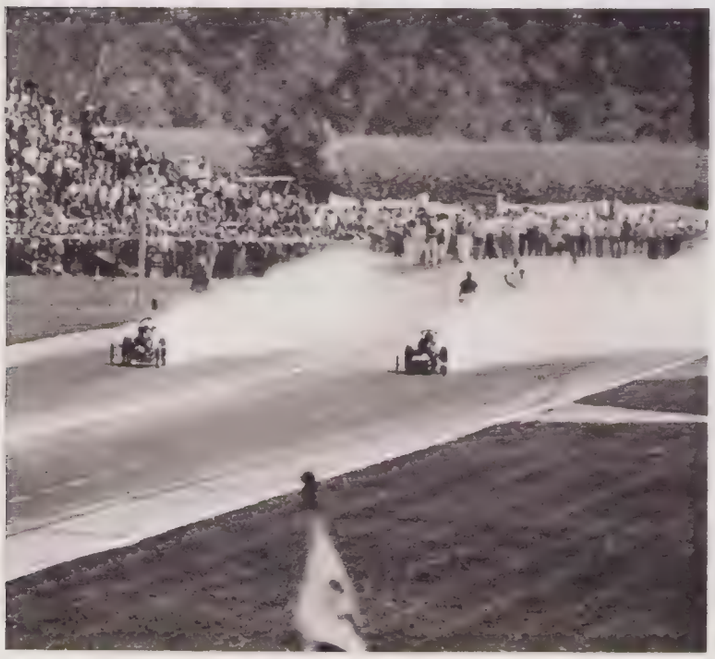
Some enthusiasts have gone a stage further and have fitted obsolescent jet engines from aeroplanes to their relics. Jet cars race at fantastic speeds approaching 250 mph.

A picture like this means drama—for at 10,000 revs per minute, clutches tend to fly apart like shrapnel. When this happens a trail of oil is left on the track, which must be cleaned up before the next race. Here track officials at the National Championship Drag Races at Indianapolis spread a compound to ensure the track is safe

PHOTOS BY LAWRENCE SCHILLER

It is hard to see the driver as he streaks off in a cloud of smoke from the screeching rear tyres. He won't be able to see much either. Fantastic acceleration is needed for a rail to reach 180 mph on a 440-yard track. How is this speed obtained? The answer is found in giant rear wheels which have no tread and rev up to tremendous speeds before the starting signal. At the 'off' the dragsters explode away from the start like a bullet from a gun

Two dragsters smoke down the course. As soon as they start, an electric timing-device is set in motion, and the one which covers the quarter-of-a-mile strip in the shortest time is the winner



THE TOUGH ONES

Which are the toughest animals? They are not necessarily the biggest or the best-known. Take the Arctic tern. It nests in a region extending far north into the Arctic Circle. As winter approaches it migrates southwards—sometimes as far as the *Antarctic* Circle.

Some Arctic terns make the full round-trip of 11,000 miles there and 11,000 miles back every year. 22,000 miles a year! It is estimated that they must travel about 1,000 miles a week and spend most of their time searching for food!

The Arctic tern—super-bird

Adaptable fish

One of the most extraordinary fishes is the small blackfish of the Arctic regions of Siberia. Every year the waters in which it lives freeze over, and for several weeks, perhaps months, the fish lies frozen within the great mass of ice. When the ice thaws in the spring the fish is still alive and resumes its activities until the following winter.

Another remarkable fish is the lung-fish, found, among other places, in small streams and swamps in Africa. Far from freezing over, its habitat dries up completely for months at a time. An ordinary fish would die instantly, but the lung-fish envelopes itself in a casing and burrows into the mud. For months on end it can lie breathing about once every two hours through a small aperture in its casing open to the air. There it remains until the rains fill up its stream.

The longest fasts

Desert animals are notoriously hardy. Perhaps the most extraordinary of them all is the Egyptian snail. This desert creature is active only when it rains, and for the rest of the time it lies dormant. In this condition it can survive for a very long time. A specimen was once brought to the Natural History Museum in London and gummed to a card. There it remained for four years, until an attendant was astonished to see a new membrane over the mouth of the snail's shell. Amazed, he put the snail into some tepid water. In a quarter of an hour it was moving about, and the following day eating cabbage!

The ability of some animals to fast is almost unbelievable. Ticks are reported to have lived up to 18 years without eating at all. But the fasting record is almost certainly held by small, parasitic worms called nematodes. In June 1945 two American scientists were examining a rye leaf which had been preserved since the autumn of 1906. It contained several dormant nematodes. When they were moistened the five little worms were found to be alive. Since they are incapable of moving on or in dry material they must have existed without any form of sustenance for almost 39 years!

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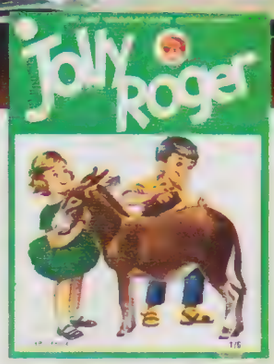
Jolly Roger

THE BRILLIANT NEW WEEKLY MAGAZINE for UNDER-EIGHTS



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A MAGNIFICENT MAP OF THE WORLD'S ANIMALS

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Brachytrypes megacephalus. This is a large, thick-bodied insect allied to the cricket. Its most characteristic feature is its enormous head, which is armed with a pair of powerful jaws. It is found commonly in oases in the deserts of North Africa, and the desert people use it for food and say it is delicious roasted. It extends just across the Mediterranean into Sicily. These crickets make burrows in the earth and sit near the mouths of them all day, chirping incessantly.

Brachytrypes megacephalus

Saga pedo. The females of this large green grasshopper may be nearly 5 inches long, including the ovipositor. Like many of the long-horned grasshoppers, *Saga pedo* feeds not only on plants but on other insects, which it seizes with its spiny fore-legs and crunches up in its jaws. It is found in southern Europe but is rather rare.

Saga pedo

Phylloptera

Mole cricket

way out between your fingers. Its voice is quite unlike that of other Orthoptera; instead of chirping it makes a loud, continuous churring sound. The female makes an underground nest in which she lays between 200 and 300 eggs. Mole crickets are common in Europe but rather rare in Britain.

Phylloptera. This is a long-horned grasshopper of tropical America. Its tegmina are shaped and coloured just like leaves, even to the extent of having a brown spot, as if the leaf were diseased or attacked by a fungus. Large, leaf-like grasshoppers of this kind afford some of the best examples known of natural camouflage. *Phylloptera* is abundant in the tropics and sings loudly all night.

ovipositor at the end of the abdomen. The total length of a female is over 2 inches. The male sings by day and night with a loud, persistent chirping.

Ephippiger bitterensis. The generic (first) name of this brightly coloured insect is derived from the Greek word for a saddle, owing to the saddle-shaped form of its tegmina; these are short, and the insect is quite wingless. It lives on the ground in open country in central and southern Europe.

Ephippiger bitterensis

Note: In the illustrations the insects are not all drawn to the same scale

The area explored by the Cabots

THE English were not particularly prominent in the 'Age of Discovery'. Christopher Columbus was Genoese and sailed in Spanish ships. Ferdinand Magellan was a Spaniard, financed by his government. However, there were two great explorers, who, even if they were not Englishmen, at least sailed under English patronage and whose discoveries and achievements were made on behalf of the English crown. And this was at a time when the English looked enviously at the vast empires being carved out by Spain and Portugal. These explorers were John Cabot and his son Sebastian.

John Cabot, or Giovanni Caboto, was born in 1450 – in Genoa, like Columbus. At an early age he went to Venice where he took part in the great trading voyages – including one to Mecca – that were the foundation of Venice's prosperity. Young Cabot was deeply impressed by the silks, spices, and precious stones he saw, and became obsessed with the idea that a quicker and shorter sea route might be found from the West to the East. Like all the great explorers of his time, he was convinced that such a route should be found by sailing west, and in about 1484 he came to London to canvass his views in England. The merchants of Bristol, one of England's greatest ports, welcomed his scheme.

Over a period of several years expeditions under Cabot's command were despatched with the object of finding the 'island of Brazil' or the 'island of the seven cities' which mediaeval map-makers inserted to the west of Ireland. Not surprisingly, the search proved fruitless, but in 1493 came the news that Columbus had 'reached the Indies'. At once it was decided to forget the islands and press straight on to the fabulous lands of Asia. On 5th March 1496 letters patent were issued by King Henry VII granting to his 'well-beloved John Cabot, citizen of Venice, to Louis, Sebastian and Santius, sonnes of the said John, full and free authority, leave and power upon theyr own proper costs and charges to seeke out, discover and finde whatsoever islands, countries, regions or provinces of the heathen and infidel, which before this time have been unknown to all Christians'.

The King's part of the bargain was that a fifth of all the gains resulting from the discoveries were to go into his treasury.

VOYAGES TO THE WEST

Cabot's expedition set sail on 2nd May 1497 to follow these instructions. It consisted of one ship, the *Mathew*, manned by 18 men. Sailing north past Ireland and then turning west, Cabot arrived at the most northerly point of Cape Breton Island, in Canada, on 24th June. He raised the English flag and took possession of the land in the name of Henry VII. This was the inauspicious beginning of England's colonisation of North America.

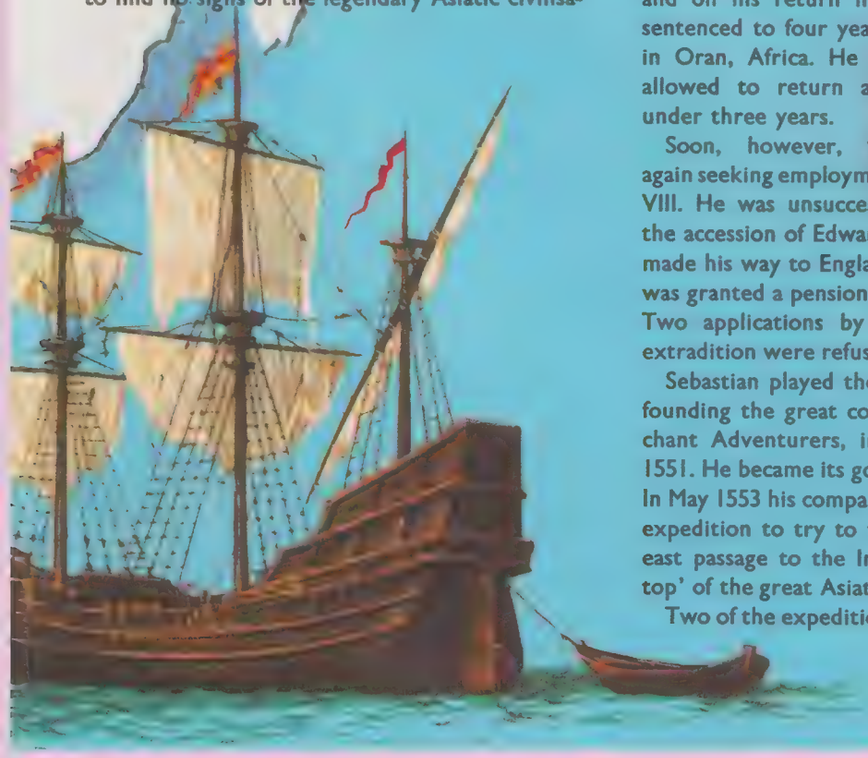
A 16th-century sailing ship

JOHN AND SEBASTIAN CABOT

But Cabot, like Columbus before him, thought he had found Asia. In a state of great excitement he returned to Bristol, naming a number of islands on the way, and docked on 6th August. As his reward for claiming part of the 'land of the Grand Khan' he received a gift of £10 from the King.

Henry accepted Cabot's proposal that a new voyage should follow the coasts southwards as far as Japan (which was thought to be near the Equator) and thus arrive at the very centre of the spice trade. Cabot was granted a pension of £20 and promised a fleet of 10 ships for the project. In fact, Cabot had only two ships when he left Bristol in the spring of 1498, though they were accompanied by a number of privately owned merchant ships. Cabot decided to search for a land in the far north which he had heard about from an explorer called Lavrador. They drifted northwards with the Gulf Stream, and early in June reached Greenland, which Cabot named Labrador's Land. The fleet continued northwards, and the cold became more and more intense. Gigantic icebergs rose out of the mists and made their progress hazardous and slow. On 11th June the crews mutinied, and Cabot had no choice but to turn about, having failed to find the north-west passage through Greenland to Asia.

Unable, then, to continue north, Cabot explored the southern coast of Greenland and then set a course west. Eventually he arrived at Baffin Island, to the far north of Canada, which, of course, he considered to be Asia. So he turned south in search of Japan. He did a little bartering in furs with Indian tribes, but in his progress down the coast he became increasingly depressed to find no signs of the legendary Asiatic civilisations. His rations were running low, so he set sail for England, arriving there in the autumn of 1498. Later that year he died.



DIVIDED LOYALTIES

Sebastian Cabot was somewhat less single-minded than his father. After early service for England, during which time he appears to have sailed in search of the north-west passage (1509), he was sent by Henry VIII to help the Spaniards against the French in 1512. He promptly joined the Spanish navy, and rose to a position of some seniority. In 1520 he returned to England to take charge of an expedition to Newfoundland. But, suddenly deciding that he should serve his own native country, Sebastian abandoned King Henry and in 1525 became commander of a Spanish-Venetian expedition 'to discover the Moluccas, Tarsis, Ophir, Cipango [Japan], and Cathay [China]'.

Sebastian's three vessels set sail from Seville in April, and in two months he reached the coast of Brazil. Turning southwards towards the Strait of Magellan, he became diverted by accounts of Spanish colonies and the enormous wealth in the country of the river Plate (La Plata). He persuaded his men to forgo the search for the spice islands and reached the Plate in February 1527.

The authorities in Seville took a dim view of Sebastian's disobedience, and on his return in 1530 he was sentenced to four years' banishment in Oran, Africa. He was, however, allowed to return after only just under three years.

Soon, however, Sebastian was again seeking employment with Henry VIII. He was unsuccessful, but after the accession of Edward VI he slowly made his way to England and in 1549 was granted a pension of £166 13*s* 4*d*. Two applications by Spain for his extradition were refused.

Sebastian played the major role in founding the great company of Merchant Adventurers, incorporated in 1551. He became its governor for life. In May 1553 his company organised an expedition to try to find the north-east passage to the Indies 'over the top' of the great Asiatic land mass.

Two of the expedition's three ships

Sebastian Cabot (from a 19th-century engraving)

became trapped by ice in the frozen northern waters and their crews perished. But the third, commanded by Richard Chancellor, succeeded in entering the White Sea, from where the captain made his way inland to Moscow. This paved the way for considerable Anglo-Russian trade agreements, and was one of the many achievements of Sebastian's company.

In May 1557 Sebastian's pension was stopped, owing to the influence of Philip II of Spain, Queen Mary's husband. However, Mary restored it after only a few days. The exact date of Sebastian's death is not known, but it is probable he died later that year. His death brought to an end an era in which the Cabot family from Italy had rendered magnificent services to England.

THE MERCHANT ADVENTURERS

The Merchant Adventurers were one of the earliest and most successful English companies which indulged in overseas trade. The Fellowship of the Merchant Adventurers London was created in 1486 and received special privileges from the King in return for their part in fostering the growing cloth trade. The Fellowship formally became a company in 1551. In the second half of the century it received almost monopolistic privileges and played a major role in extending English commerce.

LANFRANC AND SAINT ANSELM

THE Archbishops of Canterbury have naturally been a mixed bunch: saints and sinners, profound thinkers and brilliant administrators, astute and corrupt, peaceful and brilliant, and so on. Two of the greatest held office in the latter half of the 11th century and were both Italians. Their names were Lanfranc and Anselm. Both of these men came originally from north Italy. Both had distinguished academic careers. Both were reluctant to abandon their positions in the Church to take up the demanding job of Archbishop of Canterbury. But the comparison ends here, for these men were different in character and had very different roles to play in the history of the English Church.

REFORMED PAPACY

To understand the significance of Lanfranc and Anselm we must look at the Church as a whole in this period. In the first half of the 11th century the Popes, although universally recognised as head of the Christian Church, were of little more than local importance. Roman families fought and squabbled over the Papacy. But in 1049, with the election of Pope Leo IX, this changed. He began the reform of the Papacy which in less than 50 years was entirely to transform it. Leo's successors became imbued with a strong vision of the place of the Church in the world. To them the Church should be entirely independent of the State; moreover, its control and administration was a matter for churchmen. The ultimate control should be with the Pope. But what they actually saw was very different, for the Church in 1049 was very much controlled by laymen. Laymen appointed people to ecclesiastical offices, and also invested churchmen with the symbols of their office (*lay-investiture*). Sometimes laymen actually sold ecclesiastical offices to the highest bidders (*simony*). Moreover, many clergymen were married, and this again in the eyes of the Papacy made the priests part of a world from which they should have been apart.

So the Popes declared war against lay power where it interfered with the affairs of the Church. The movement was gathering momentum when William the Conqueror came to the English throne in 1066. He came with the support of the Pope and must have paid lip-service to all the papal ideals. But when he became King of England he naturally saw the Papacy in a very different light. It was all right for the Popes to wish to control the Church – the trouble was that there was a Church *temporal* as well as *spiritual*. Bishops were great lords: they held large portions of the English land and provided many knights for the royal service. It was quite impossible for the King to lose control of bishoprics by letting the Popes do the appointing and investing. It would have been rather like letting the King of France appoint English tenants-in-chief (major landowners).

However, on his accession William's immediate problem was to make the English Church an ordered and component part of the Norman State. In 1070 he gained the deposition of the Anglo-Saxon Archbishop of Canterbury and chose in his place Lanfranc, the scholarly Abbot of Caen.

LANFRANC – THE KING'S MAN

Lanfranc was born early in the 11th century in Lombardy. He studied law and philosophy under distinguished masters. After a period of teaching at Avranches he arrived at Bec, in Normandy, where he set up a school under its talented abbot, Herluin. The school was a tremendous success and attracted many intelligent young men from all over Europe. William, Duke of Normandy, made use of this brilliant man who had settled in his dominions. Lanfranc even negotiated with the Pope on William's behalf. In 1066 he became abbot of William's abbey at Caen. Yet he did not seem interested in high ecclesiastical office. In 1067 he had refused the offer of one of France's foremost archbishoprics, Rouen, and it was only under protest that in 1070 he allowed himself to be made Archbishop of Canterbury.

Both William and Lanfranc saw the need for order and organisation in the English Church. One of Lanfranc's first moves was to have it laid down that the Archbishopric of Canterbury was superior to England's other archbishopric, York. Having obtained this recognition for the time being, he could begin his reorganisation of the English Church. Norman bishops and abbots were appointed. Seats of bishoprics were moved from small villages into larger towns. Bishops were told to hold regular diocesan councils. Priests had to ask a bishop's permission before leaving their diocese. Many new churches were built. The marriage of clergy was condemned – clergy who were already married did not have to put away their wives, but those unmarried could no longer marry. Special Church courts were set up

St Anselm (1033–1109)

A monk of Canterbury in the 12th century

– though these were to be the cause of considerable friction between Henry II and Becket (see page 604).

The Popes eyed the doings of William and Lanfranc with mixed feelings. There could be no doubt that much-needed reforms had been effected in the English Church. Clerical marriage and simony had been halted. Good men had been made bishops and abbots. The English Church was certainly one of the best-ordered in Europe. And yet William and Lanfranc were deaf to the Popes' strictures on lay-control and lay-investiture. Moreover, they refused to let the Pope exercise any authority over the English Church. This infuriated Pope Gregory VII who wrote: 'No king, not even a pagan king, has presumed to act against the Apostolic See in the way that William unblushingly has acted.' William was quite firm with the mighty Gregory. He informed him that without his consent: no Popes would be recognised in England; no letters from the Pope (he obviously had in mind letters demanding homage!) should be allowed in; no bishops would be allowed out; and none of his tenants-in-chief would be excommunicated. There was little Pope Gregory could do unless he wanted to excommunicate two men renowned for the serious reforms that they had effected in their Church, and add another ruler to the list of his political enemies.

In 1087 the Conqueror died. Two years later he was followed to the grave by his archbishop. William Rufus (see page 1729) was now on the throne. He possessed his father's strong personality and some of his talents, but was corrupt and unbalanced. For nearly four years Rufus unscrupulously appointed no successor to Lanfranc while he received the revenues of Canterbury. But when he fell ill at Gloucester he decided to do penance for his sins and appoint an archbishop. At this time the Abbot of Bec, Anselm, was in the country. Already he had a reputation for his saintly life and great scholarship. William chose him to be his archbishop. But only after a great struggle did Anselm accept the office.

ANSELM – THE PAPALIST

Anselm had been born in Piedmont in 1033. He had come to Bec attracted by the fame of Lanfranc's teaching. In 1060 he became a monk there. In 1078 he succeeded Herluin as abbot; about this time he completed some of the great philosophical and theological works which earned him a European reputation.

Rufus and Anselm were soon quarrelling. First William claimed that he alone in England had the right to recognise a new Pope and that Anselm should not presume to do so before him. But a more serious quarrel occurred over Anselm's demand to visit Rome. Although, through lack of support from the English bishops, Anselm had to forgo his demand in 1095, in 1097 William was forced to let him leave. But immediately Anselm was out of the country the unscrupulous King seized all the revenues of Canterbury.

When Anselm arrived in Rome he was received with great honour by Pope Urban II. He was chosen to represent the Roman Church in a debate against the Greek Orthodox. Shortly after this he finished his greatest theological work, *Cur Deus homo*. In 1100 Rufus was killed, and his brother Henry recalled Anselm.

Anselm's contact with the Papacy had made a deep impression on his mind, and in 1099 he had heard decrees of excommunication against churchmen who were invested by laymen, and laymen who invested churchmen.

At first it looked as if Henry was going to be a marked contrast to Rufus. He appointed bishops and abbots to the sees and abbeys from which Rufus had been deriving a considerable income by keeping vacant. But on the question of investitures, which Anselm brought up soon after his arrival, he would not compromise.

Anselm refused to consecrate the new bishops invested by Henry, and in 1103 retired to Rome from where he excommunicated a number of these English bishops who had been invested by the King. However, in 1106, after negotiations between Pope Paschal II, Henry, and Anselm, a famous compromise was reached, known as the Compromise of le Bec. The King relinquished his right of investing the bishops with the ring and staff. On the other hand, he did not lose his control over appointments, for Henry saw to it that bishops had to do homage to the King for the land attached to their bishopric – *before* their consecration. However, the Church made two important gains from this: first it had made Henry step down on a matter about which his father and brother would have heard no argument; and secondly, it had removed the hands of laymen from one more aspect of the Church's life.

Anselm died in 1109. His last years were spent peacefully. In 1163 proceedings were begun for his canonisation.

William's followers pay homage to a banner given to him by Pope Alexander II before his invasion of England. On William's left is Lanfranc, then Abbot of Caen

THE AMERICAN CIVIL WAR

THE rift between North and South had been widening for some time. In the South the wealthy, well-bred landowners depended on the labour of black slaves. But the more industrialised Northern communities were opposed to slavery. Moreover, the South condemned the economic policy of the North. In order to protect their own industries Northern businessmen wished to restrict the import of foreign manufactures. In addition there was the mutual antipathy of the proud, cultured Southerners for their brash 'Yankee' fellow-countrymen of the North.

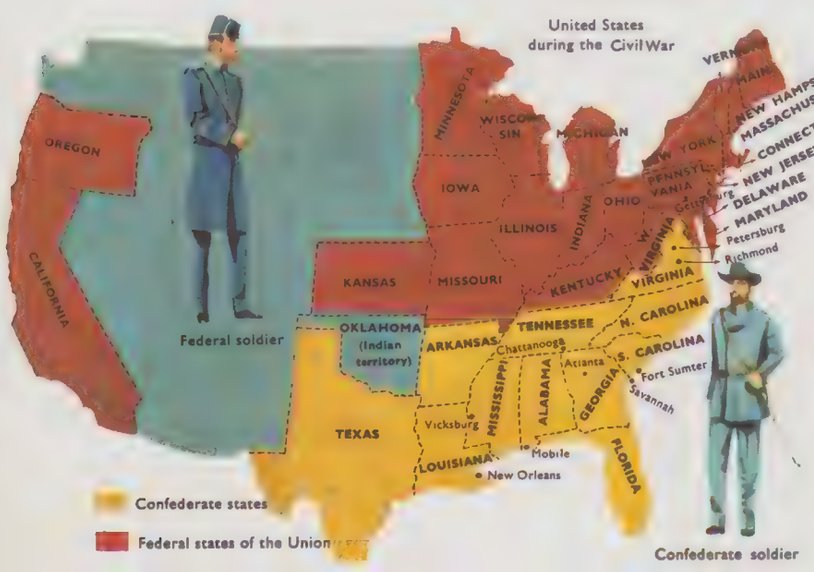
In November 1860 Abraham Lincoln was elected President of the United States. He was known as a 'black Republican', on account of his opposition to slavery. Although he said he would not abolish slavery in states where it existed, he was determined that it should not be extended to the new states in the west. The slave states of the South had no intention of being ruled by Lincoln, and in December 1860 South Carolina announced that she had seceded from (left) the Union, meaning she was no longer a member of the 'United' States. By the time Lincoln was inaugurated as President in March 1861 six other slave states – Florida, Georgia, Alabama, Mississippi, Louisiana, and Texas – had followed South Carolina. They formed a new union of their own – the Confederate States of America – and elected a distinguished soldier, Jefferson, as their President.

Lincoln was convinced that the Southern states had no right to leave the Union. But could he use force? The question was decided for him when in April 1861 the Confederates forced Federal troops to surrender Fort Sumter outside Charleston. Lincoln regarded this as an act of insurrection or revolution. He summoned 75,000 soldiers, and the North prepared to restore the Union by force. In the South, Virginia, Arkansas, Tennessee, and North Carolina joined the Confederates; the scene was set.

Robert E. Lee, Commander-in-Chief of the Confederation

Advantages of the North

On paper the South was much weaker than the North. She lacked the North's productive capacity and consisted of 11 states as opposed to 23. Her population was less than half the North's, and after secession the Confederates had to create new instruments of government and administration. And the South was far from 'solid'. Many people in Georgia, Alabama, Mississippi, and Louisiana supported the North, while the West Virginians formed a separate state and joined the Union later in the war. The South's prosperity depended upon exports, but the American navy, supporting the North, blockaded the Southern ports, so preventing the export of her staple crop, cotton. The Southerners made one attempt to gain naval supremacy. In 1863 they fitted a captured frigate with ten guns and plated it in armour. This ship, the *Merrimac*, caused havoc until another iron-clad ship, the *Monitor*, was launched by the Union against her. In their first encounter



12th April 1861. Confederate troops bombard Fort Sumter, above which flies the flag of the Federal government. This was the first drama of the Civil War

Merrimac was defeated.

The South did have a few advantages. Her generals were superior and her soldiers more used to handling firearms.

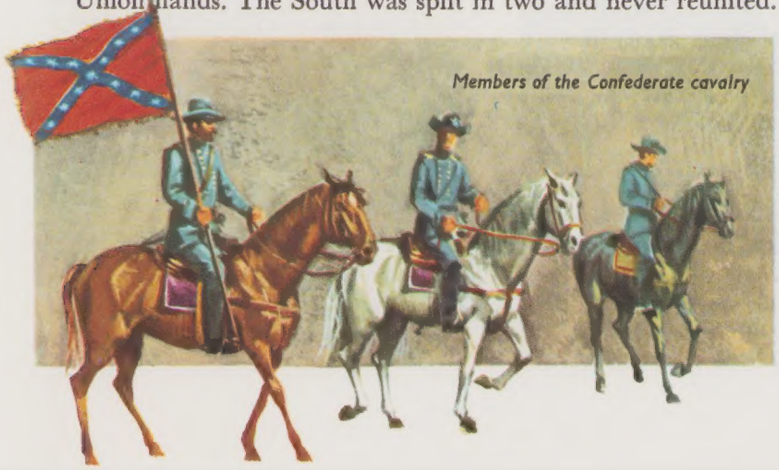
Invasion of the South

The Confederacy had gathered an army of 400,000, but its strategy was defensive. It fully expected France and Britain to intervene on its behalf. Yet the European countries remained neutral; the South stood alone.

Lincoln was faced with two main areas to attack. The Southern states were divided into east and west by the Appalachian Mountains. In the east, Virginia, which included Richmond, the Confederate capital, was all-important, and most of the eastern fighting took place there. But victory in the west would divide the Confederacy completely in two, and so was equally important.

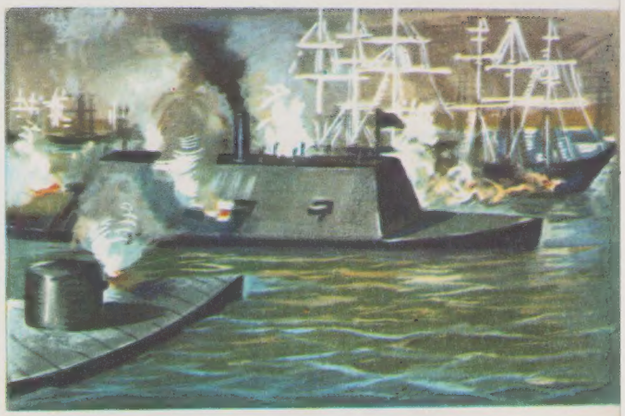
The first major campaign of the war was disastrous for the Union. An army descended into Virginia to make an onslaught on Richmond; it met the Confederates under General Beauregard near the little stream of Bull Run and was overwhelmingly defeated. Lincoln realised that to take Virginia would be a long and arduous business.

In the west, however, events were more encouraging for the Union. Before the end of 1861 Union troops had consolidated their position in Missouri. Early the next year they marched under General Grant into Tennessee and on 6th February forced the Confederates at Fort Henry to surrender. From then on Confederate strongholds were destroyed one by one, and by 1863 Union troops were in Upper Mississippi and Alabama. Grant now left other officers to deal with the Confederates in Tennessee and concentrated on the assault of Vicksburg, the Confederate stronghold on the Mississippi. He starved the Confederate general into surrender on 14th July. Shortly afterwards Port Hudson, Louisiana, was taken by one of Grant's officers. As New Orleans had already been seized by the American navy the whole Mississippi was now in Union hands. The South was split in two and never reunited.



Members of the Confederate cavalry

Meanwhile Lincoln had taken advantage of Union victories to make the momentous proclamation of 1st January 1863 abolishing slavery in the United States. This was to be the most enduring achievement for which he is remembered.



The huge, armoured Merrimac *encounters the Federal ship,* Monitor

A costly war of attrition was now taking place in the east. The Virginian army under the Southern General Robert E. Lee and his able lieutenant Colonel 'Stonewall' Jackson (who had gained his nickname at the battle of Bull Run) was powerful and confident.

In 1863 Lee invaded Pennsylvania and was only stopped by a decisive defeat at Gettysburg in July. Yet in early 1864 Lee's army still appeared an insuperable barrier to Union hopes.

The final stages

In May 1864 General Grant, now commanding all the Federal armies, took charge of the Virginian campaign. In a determined drive on Richmond he thrust his way south, heedless of heavy losses. He crossed the James river and laid siege to Petersburg, near Richmond. Meanwhile General Sherman had begun his campaign from Chattanooga to Atlanta. 'Marching through Georgia', he laid that state waste, destroying everything in his path. In December Savannah fell, and Sherman turned north and pushed into Virginia.

The pincers were closing in on Virginia, and the war was in its final phase. On 2nd April 1865 Petersburg fell to Grant. The next day the Unionists entered Richmond, hurriedly evacuated by the Southern President Davis. Lee's unconquered army was racing westwards, slowly pursued by Grant and with another Federal army under General Sheridan on its flank. On 9th April Lee surrendered, having given up a plan to join General Johnston in North Carolina. A fortnight later Johnston surrendered, and in the west General Kirby Smith laid down his arms. The war was over.

The cost of the American Civil War was enormous. About 600,000 men were killed and hundreds of thousands wounded or crippled. The total cost of the war has been estimated at over 10,000 million dollars.

The war had results of immense significance for the future. The emancipation of the slaves was ensured despite Lincoln's assassination in the year of victory, and the Union was consolidated and enabled to grow into the great nation which was to play such a decisive role in world politics in the next century. But the feelings and hatreds generated by four years of Americans fighting Americans left differences of outlook which were to prove lasting and scars which have perhaps not been fully healed to this day.

Ulysses S. Grant, Federal Commander

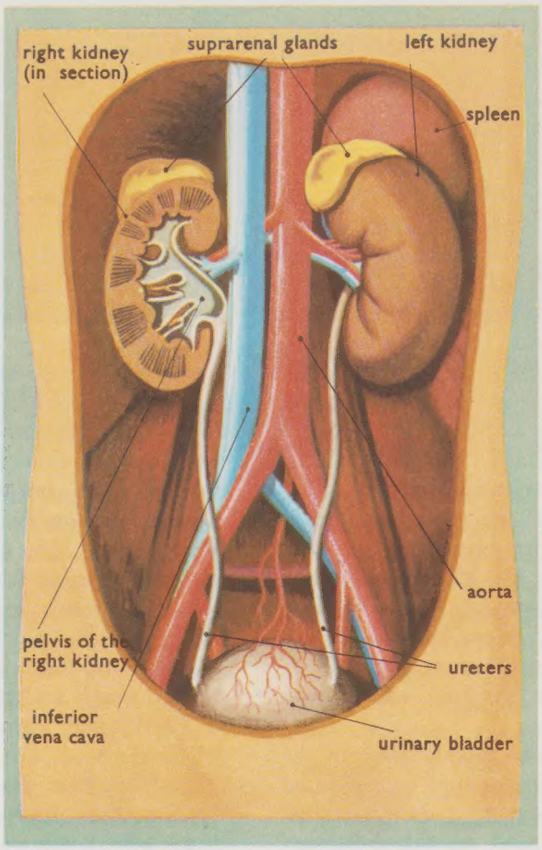
BRIGHT'S DISEASE

THE portraits of many celebrated doctors gaze down from the walls of the Royal College of Physicians in London, but none does so more benevolently than that of Richard Bright. Traveller, artist, and physician, he was a man 'of remarkably even temper and cheerful disposition'. He was also a man of great industry and insight, and it was these qualities which enabled him to recognise, before any other doctor, the strange disease of the kidneys which to this day is known as Bright's disease.

Richard Bright

Richard Bright was born in 1789, the son of a wealthy Bristol banker. He studied medicine in Edinburgh and at Guy's Hospital in London, qualifying as a doctor in 1813. Instead of setting up in practice immediately after qualification, however, he left England for an extended tour of Europe, remaining abroad until 1820. On his return he worked in a fashionable practice in London, and in quite a short time he was appointed Assistant Physician at Guy's Hospital. Four years later, in 1824, he was promoted to Physician.

Richard Bright was not only a very hard-working doctor; he was also a very astute one. Quite soon after his appointment to Guy's Hospital he realised that patients with the swelling of the limbs known as *dropsy* often had *albumin* in their urine. He saw also that these two features were in some way associated with disease of the kidneys. To confirm his idea he began to investigate the problem, working at it six hours a day for many months. By 1827 he had discovered the basic facts of the disease which now bears his name, and thus he became one of the most famous physicians of all time.



This dissection shows the arrangement of the organs of the urinary system within the abdominal cavity

The function of the kidneys

To understand the nature of the illness which Richard Bright discovered it is first necessary to know a little about the physiology of the kidneys. In a normal adult there are two of these organs and their task is to remove from the blood, and therefore from the body as a whole, unwanted water and the products of bodily metabolism, particularly the nitrogenous waste, *urea*. The blood which reaches the kidneys along the renal arteries is channelled to the outermost part of the kidney substance, where it passes through thousands of tiny tufts of thin-walled capillaries known as *glomeruli*. The unwanted waste materials in the blood escape through the thin capillary walls of these glomeruli, and after being collected in the *capsule* which surrounds each glomerulus they pass down a long and tortuous *tubule* to reach the *pelvis* of the kidney. The fluid which collects in the pelves of the two kidneys is known as the *urine*.

What causes Bright's disease?

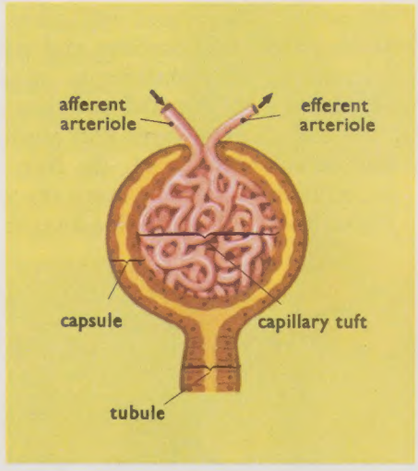
Although it is now more than 100 years since Richard Bright discovered the disease which bears his name, the cause of this illness is still not completely understood. We do know, however, that many attacks follow infections of the throat, particularly tonsillitis, and that the basic lesion in Bright's disease is a severe degree of inflammation of the kidneys; many doctors call the disease *nephritis* (from the Greek *nephros*, a kidney).

The illness

The onset of Bright's disease varies considerably. Some of its victims are suddenly and acutely ill, while others may lead normal lives for years without knowing that they have the disease. It is not unknown for Bright's disease to be recognised for the first time when its unsuspecting victim goes for a routine medical examination.

The symptoms of the illness, although they differ greatly from one patient to another, are almost all attributable to the inflammation of the kidneys. Thus when the inflammation is severe – though not necessarily permanent – not only does albumin escape from the blood into the urine but so, too, do a number of red cells. Consequently the urine is tinged with red. In many cases there is impairment of the secretory function of the kidneys, so that unwanted salt and water are retained in the body, and dropsy results. In other cases *urea* is not excreted sufficiently rapidly, and the level of this waste substance in the blood steadily increases.

The treatment of Bright's disease consists of rest in bed until the inflammation of the kidneys subsides. In some cases, however, the glomeruli are so seriously damaged that they are unable to function normally again, and as a result some of the symptoms of the illness persist.



This diagram of a glomerulus shows how the waste products may escape from the capillary tuft into the lumen of the tubule

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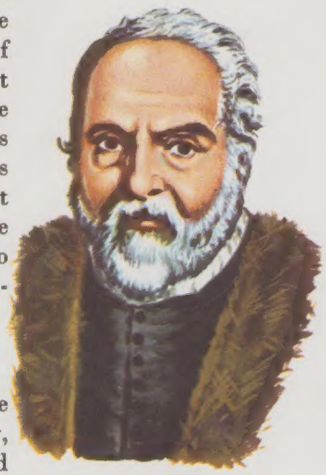
work (which had been lost for centuries) was re-introduced, and so there was some increase in knowledge. Unfortunately it was considered that his work was final and attempts to criticise or improve on it were discouraged. Research and observation were regarded as unscholarly and even impious, and little progress in natural science was made.

Renaissance progress

With the Renaissance came a new spirit of enquiry, although it was rather slow in getting under way. Rondelet (1507–1566), a Frenchman, made a study of the fishes of the Mediterranean and added greatly to the current knowledge of them. The Swiss scientist Konrad Gesner (1516–1565) and the Italian Ulissi Aldrovandi (1522–1605) both wrote books of many volumes about animals. Gesner's *Historia Animalium* (*History of Animals*) was the most important of these works. Although its classification was less scientific than Aristotle's, it contained accurate descriptions of a large number of animals and it broke away from the scholastic tradition of ignoring everything that was not mentioned in classical writings. The most important early work on insects was by an Englishman, Thomas Moufet (1553–1604); it is thought that the nursery rhyme about Little Miss Muffet and the spider refers to his daughter, but this cannot be regarded as certain.



Ulissi Aldrovandi

The microscope

Modern zoology really dates from the second half of the 17th century, when a whole new world was opened up by the invention and development of the microscope. The first man to produce a real microscope was van Leeuwenhoek (1632–1723), a Dutch lens-grinder who produced an instrument that magnified 270 times; previous microscopes could magnify only about 10 times. He was the first human being to see protozoans (one-celled animals) and bacteria. His countryman and contemporary, Swammerdam, was interested mainly in invertebrate animals. His investigation of the life of bees is famous, and he made the first detailed studies of the metamorphism of insects – that is, of their changes through the egg, larva, and pupa stages. The Italian Malpighi (1628–1694), one of the greatest early microscopists, had the outlook of a modern scientist. His monograph on the anatomy and life of the silkworm was the first serious attempt to describe an invertebrate animal in detail.

One of the early microscopes

Despite such scientists, belief in spontaneous generation persisted until quite recent times. Final proof that all life springs from pre-existing life was the work of the famous French biologist, Louis Pasteur.

Carolus Linnaeus, the Swedish systematist, examining an insect

Order is introduced to the animal kingdom

Modern classification of animals began with the work of the great English naturalist John Ray (1627–1705). He laid the foundations for the first systematic classification of the animal kingdom, which was produced half a century after his death by the Swede Carolus Linnaeus, who was born in 1707. Linnaeus's most important contribution to biology (he was both botanist and zoologist) was his establishment of the *binomial* nomenclature, by which every living thing is known by two names: the first being that of the genus in which it is included, the second that of the species to which it belongs. Thus the house-sparrow and tree-sparrow are both included in the genus *Passer*: the first being the species *Passer domesticus*, the second *Passer montanus*. The names are in Latin so that they are suitable for use by speakers of any modern language. Linnaeus also invented the system of classification under which genera (plural of genus) are grouped into Orders and Orders into Classes. This system, as well as his method of naming, is followed (with various improvements) today. The tenth edition of Linnaeus's *System of Nature*, published in 1758, is regarded as the starting point of modern classification.

Linnaeus's work on zoology was continued in the late 18th and early 19th centuries by two French naturalists, Lamarck and Cuvier. Among other things they elaborated the classification of the invertebrate animals, and their work brought zoology to the dawn of modern times.

Georges Cuvier, an eminent French zoologist

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The theory of evolution

Apart from Lamarck all the naturalists we have mentioned believed that every species of animal resulted from an act of creation, and that, once created, species never changed. Lamarck thought that characteristics acquired by an animal in its lifetime could be handed on to its offspring – for instance, that the children of a blacksmith would have strong arms because their father had developed his muscles in the course of his work. If this were so modern animals could have come into being, by descent through gradual change or evolution, from previously existing and quite different ones. But Lamarck failed to convince anyone of the truth of his theory.

Charles Darwin (1809–1882) also thought that species had arisen by evolution, but he accounted for it in a different way. Just as fancy breeds of dogs can be produced by selecting the desired varieties to breed from, so will nature select those varieties which are best fitted to survive. In his book *The Origin of Species*, published in 1859, the case for believing that evolution has taken place was convincingly stated, and his theory of natural selection was proposed to account for it.

Charles Darwin, author of the theory of evolution by natural selection

The evolution of the elephants (from the left): Moeritherium (Eocene); Trilophodon (Miocene); mammoth (Ice Age); elephant (present day)

Modern zoological research

The work of describing and classifying the animal life of the world has gone steadily on since the time of Linnaeus. Every year thousands of new species are discovered and named, especially among the insects. Over 700,000 different species of insects have been classified and named up to the present time, but entomologists (people who study insects) believe that an even larger number still remains to be discovered. On the other hand, the finding of a new species of bird or mammal is a rare event.

A great deal of work on the heredity or genetics of animals has been done in the present century, and the process by which characteristics are handed on from one generation to the next is now well understood. The understanding of it has placed Darwin's theory of evolution by natural selection on a firmer basis than ever.

The study of animal behaviour, or ethology, now receives a great deal of attention from zoologists, and the same is true of animal physiology.

THE DIVISIONS OF ZOOLOGY

The study of zoology is divided into a number of branches, and most professional zoologists specialise in one of them.

Some animals discovered in the present century: a crow-like bird found in 1939; the okapi, discovered in Africa in 1901; a small beetle, one of the thousands of new insects found every year

Taxonomy. The naming and classifying of animals under the system invented by Linnaeus.
Palaeontology. The study of animals which became extinct long ago and are now represented only by fossils.
Zoogeography. The distribution of animals on the earth.
Ecology. The relation of animals with their environment.
Comparative anatomy. The study of the bodily structure of animals, comparing one with another.
Animal physiology. The study of vital processes, such as respiration or digestion.
Embryology. Animals in an early stage of development.
Economic zoology. Animals in relation to human economy.
Parasitology. The study of parasitic animals, which live and feed in or on the bodies of other animals.
Animal pathology deals with disease in animals and methods of treating and curing it.
Ethology. The study of animal behaviour.
Animal genetics deals with the mechanism of heredity in animals by the study of chromosomes and genes.
Mammalogy. The study of mammals.
Ornithology. The study of birds.
Herpetology. The study of reptiles.
Ichthyology. The study of fishes.
Entomology. The study of insects.
Malacology. The study of molluscs.